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THE ROYAL ENGINEERS JOURNAL.

VOLUME V.

JANUARY TO JUNE, 1907.

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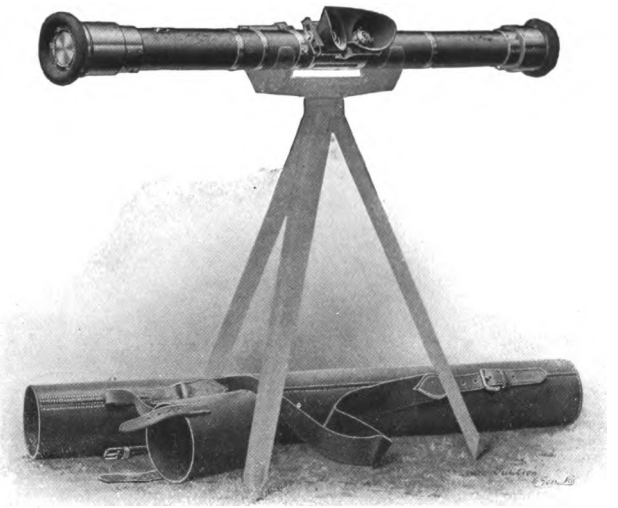

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LIGHT BRIDGING IN BURMA.

By CAPT. D. FORSTER, R.E.

DURING the cold weather of 1905 No. 15 (Burma) Company of the 2nd (Queen's Own) Sappers and Miners proceeded to the village of Shwezayan on the Myitngè river, about 20 miles from Mandalay (the headquarters of the Company), for three weeks' bridging practice.

The British Officers were Lieuts. D. Forster, R.E., and (the late) C. W. Bushell, R.E.; and Lieut.-Colonel F. J. Anderson, R.E., the Commandant of the "Q.O." Sappers and Miners, who had come over from Bangalore to inspect the Company, was present during the first few days of the practice.

A suitable and pleasant site for the camp was found close to the village in a mango grove on the banks of the river.

The following stores were brought from Mandalay in addition to ordinary tools:—

1 small boat (a 15-ft. gig).
84 ft. of light pontoon bridge, carried by 13 mules.
100 fathoms 3-in. steel rope.
200 do. 1-in. do.
1 traveller for 3-in. rope.

The R. Myitngè, which drains a large portion of the Northern Shan States, emerges from the Shan Hills a few miles above Shwezayan, where it has an average breadth of 180 yds., and joins the Irrawaddy 7 miles south of Mandalay.

The country round Shwezayan is flat. It is covered with dense jungle, mostly low bamboo, interspersed with patches of cultivation and, near the village, with lime and mango orchards.

The work carried out consisted of

(i.). Flying Bridges over the R. Myitngè.
(ii.). Bamboo Bridge over a creek of the Myitngè.
(iii.). Timber Trestle Bridge over the Nadaungchachaung (a tributary of the Myitngè, which flows into it a little below the site of our camp).
(iv.). Overhead Cable-Way over the Nadaungchachaung.
(v.). Pontoon Bridge over the Nadaungchachaung.
(vi.). Rowing practice.

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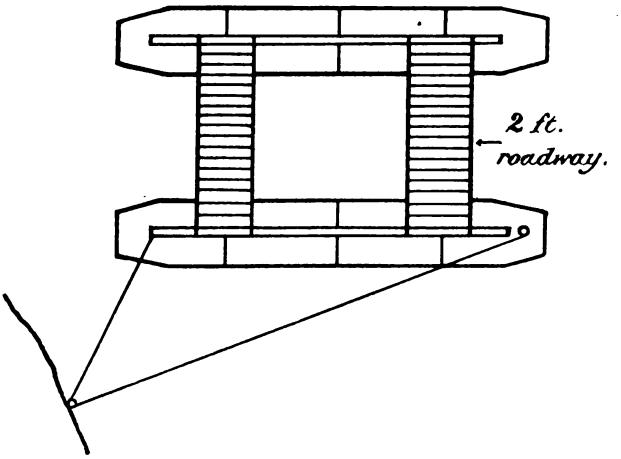
FLYING BRIDGES.

The Flying Bridges consisted of an overhead cable of 1-in. steel rope, carrying a small single block, to which the raft was attached. The ends of the cable were secured on either bank at a height of about 35 ft. above the water, the span being about 800 ft. There was an island on the south side, separated from the bank by a creek 60 ft. wide.

Two kinds of rafts were used. The first was made with the light pontoon equipment as shown in figure; this carried about 20 men.



The other kind was made with two native 'dug-out' canoes, about 25 ft. long, placed 12 ft. apart and connected with a bamboo deck (see *Photo* 1). This took 50 men, and crossed the river in 3 minutes.

Bamboo landing stages were erected, projecting 25 feet into the stream.

BAMBOO ARCH BRIDGE.

To complete the crossing a Bamboo Bridge was constructed over the creek on the south side (see *Photo* 2).

The bamboo in the neighbouring jungle was too small to be of any use, so 1,000 bamboos, about 15 ft. long and $1\frac{1}{2}$ in. diameter, were purchased from a raft going downstream.

It was originally intended to make the crossing with one 'fascine arch,' with a clear span of 70 ft.; but the bamboo was too small and green, and trestles had to be used as well. The bridge sloped up to the south bank at about $\frac{1}{12}$.

TIMBER TRESTLE BRIDGE.

There is a village named Kyauk-o, half a mile from Shwezayan and just across a ford on the Nadaungchachaung. At this ford the east and west banks of the river are 20 ft. and 30 ft. high respectively, and the width of the stream 40 ft.

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A timber trestle bridge was constructed, with the roadway on a level with the east bank (see *Photo* 3). The total length was 140 ft., the centre span being 20 ft. and the remainder 12 ft.

There were two tiers of trestles. The first consisted of piles, 5 to each trestle, driven with a Norton's Tube Well monkey. The second tier was built up with trestles made on shore and placed with the help of the traveller on the overhead cable.

All the timber was cut in the jungle, some at a considerable distance, except that for part of the roadway; for this some old teak posts, which had belonged to a Burmese bridge further downstream, were used.

The 3-in. overhead cable was taken over the forks of trees on either bank, and was of great use.

PONTOON BRIDGE.

A Pontoon Bridge was made just below the trestle bridge, for use during the construction of the latter.

The pontoons, which were made in the Company's workshops at Mandalay, are very similar to those shown at the end of the old Vol. III. of *Instruction in Military Engineering*, except as follows.

The superstructure consists of a 2-ft. roadway supported by 3 folding roadbearers of teak, 12 ft. long, with two hinges, the centre portion being 2 in. × 4 in. and the end thirds tapering to 1 in. × 4 in.

The roadway consists of teak battens, 2 in. × 1 in., fastened together with 1-in. rope, leaving 1 in. space between battens so that the whole will roll up. Successive lengths of 12 ft. are fastened together with small iron hooks and eyes. No ribands are required; a 1-in. rope handrail along one side is provided.

BAMBOO SUSPENSION BRIDGE.

In January, 1905, the Company proceeded to the Shan Hills for manœuvres, etc.

The Left Half Company, under Jemadar Maungaungbaw, made two bridges from verbal instructions.

(1). A Suspension Bridge of 60 ft. span, which was made with creepers and bamboos growing in the vicinity (see *Photo* 4). This would take infantry at about 3 paces interval.

(2). A 'Fascine Arch' Bridge with 30 ft. clear span, similar to that mentioned above, but without the aid of trestles.

BAMBOO OBSERVATORY.

They also made a Field Observatory in rear of an entrenched position near Maymyo. The uprights were single bamboos 50 ft. long. The whole of the bamboos were bought in a neighbouring village, and cost only Rs. 3/8 (4s. 8d.).

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THE CAMPAIGN OF THE FUTURE.

A POSSIBLE DEVELOPMENT.

By CAPT. C. E. P. SANKEY, R.E.

"GENERALLY speaking an engagement between two hostile forces, be they large or small, begins either by one side in motion attacking the other while stationary or by the collision of both sides when in movement.

The exceptional case of troops meeting when both hostile forces are stationary is, I regret to say, omitted in the Drill Book" (Major-General George D'Ordel in *Tactics and Military Training*).

The last para. is an example of a true word spoken in jest. It has been noticed by the more modern writers on the attack and defence of permanent works of fortification that the formerly sharp line of demarkation between these operations and those connected with the collision of two armies in the field has become considerably less distinct, but it is doubtful if strategical and tactical writers have given this point the attention it deserves. In olden days there was a very great difference between the etiquette and science appertaining to the investment and capture of a citadel on the one hand, and on the other to the conflict between two manœuvring hosts.

As mentioned above, this distinction has gradually become less and less defined, and now some of our recent experts on fortresses (for instance, Capt. Thuillier, R.E., in *The Principles of Land Defence*) state that the types of entrenchments and parapets suitable for even first-class permanent works are little, if at all, heavier or more complicated than those employed by a field army on the defensive.

The point to be noticed, however, is that this modification is also operating at the other end of the scale, and that the types of trenches suitable for field armies are gradually becoming more and more like those employed in permanent works.

The logical outcome of this continued approach from two extremes is a common mean, where it will be difficult to say whether a force acting on the offensive is attacking an entrenched and defensive field army or an enemy holding a fortress, improvised in some haste, perhaps, but still a fortress.

The experiences of the recent Russo-Japanese war will to a very great extent bear out this theory. Whereas formerly the operation of reducing a fortress possibly occupied years and a battle was an affair

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of hours, the sieges of this campaign have been measured by months and the battles by days. Moreover the Japanese, even on the offensive, have almost invariably entrenched themselves at the completion of each phase of the attack. May we not expect that in conflicts between two powers, not more individually civilised than these combatants but operating in a more civilised theatre of campaign and employing considerably larger forces, sieges and battles will both be reckoned in weeks and will be in fact indistinguishable ?

Take a case of two of the larger European continental nations, having a common frontier of say 1,000 miles, being at war. The number of men that each can put into the field would probably be between 2 and 4 millions, that is 2,000 to 4,000 men per mile of common frontier, which number does not differ very largely from the most recent estimate of that required for a modern fortress.

Moreover this common frontier will be secured, probably on each side, by a chain of fortresses, which, being constructed and maintained in peace, may be called permanent. With modern specialised arrangements for mobilisation, there will probably be no time for one side or the other to reduce any of these strongholds before their opponents are prepared ; and there is no need to point to the danger of advancing past these hostile fortresses, situated, as they would surely be, upon the main arteries of traffic that would form the lines of communication.

What then will be the result ? The cavalry forces of both sides will be hurriedly mobilised, and pushed forward as far as prudence allows ; contact will therefore be probably obtained along some line, which will be between the hostile chains of fortresses and only limited in extent by the length of common frontier. The infantry, mobilised perhaps as quickly but moving more slowly, will arrive on either side of this line and will take up entrenched positions, the flanks of which will be secured by political rather than by natural obstacles. The heavy artillery will be slower still, but will also be of a more formidable nature than what has hitherto been considered the maximum possible for a field army.

If, during these preliminary stages, neither side has blundered badly, allowing a keen-witted and daring enemy to strike a quick blow, the situation will be that each force will have taken up an entrenched position within striking distance of the other, a compromise being effected between (*a*) choosing the best topographical line of defence, (*b*) being within reach of the enemy, and (*c*) conforming to the general line of the permanent fortifications. Each army will then practically become the garrison of an enormously extended fortress, the original permanent works becoming the pivots of the line.

From this situation whichever side assumes the offensive will also assume the *rôle* of a force besieging one of these fortresses, with the consequence that all the artifices peculiar to this species of warfare will

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be employed, such as sapping and mining, the use of heavy siege guns, howitzers, and mortars, etc., etc. Moreover the attack, considered as a whole, will be frontal, although of course flanking movements will still be possible on a small and local scale.

As experience has shown, these operations are not affairs of a few hours or days only ; and with the highly civilised condition of to-day a state of war between two countries cannot be allowed to extend for an indefinite period, interfering as it does with the trade of the whole world. Also, with the concentration of events in modern warfare, due principally to quicker modes of transport, it is doubtful whether the people of the combatant nations themselves will stand the moral strain for periods as protracted as of old ; and, further, the financial strain of maintaining these huge forces will be enormous. The newspaper correspondents will be another powerful factor in this direction.

Hence the side that first penetrates the opposing defences, thus winning a victory—it may be a local one only—will probably be considered by the surrounding nations to be the victor ; and the other side also will be compelled by them to acknowledge this fact, and to pay an indemnity or cede territory as the case may be.

It has always been held that the life and growth of nations may be compared to that of man individually, though on a larger and more protracted scale. May we not here trace the same analogy ? Formerly, and not so very many centuries ago, when two individuals became foes, their enmity entailed conflict on every occasion, the quarrel only ceasing on the death of one or other of the adversaries. Latterly, in the period of the duel, honour has been satisfied by the drawing of first blood (often in microscopical quantities). More recently again there is reason to hope that even this speedily-determined species of combat may become obsolete. To draw the parallel—in other ages the cost of defeat in a campaign was extinction as a nation ; nowadays an indemnity or the loss of outlying possessions is thought sufficient, though a lengthy war is still deemed necessary to discover the victor. May we not consider that in the future one battle will be the test, that side obtaining the victory which first penetrates the enemy's fortress ?

It would be beyond the scope of this present essay to continue the analogy to that peaceful and possibly distant future when the wolf shall dwell with the lamb and the leopard lie down with the kid.

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BREEZE CONCRETE IN ROOF COVERINGS.

By LIEUT.-COL. W. H. SYKES, LATE R.E.

I HAVE recently had the opportunity of observing the erection (under the superintendence of Mr. Ralph Nevill, F.S.A.) of a house and stables, wherein the employment of breeze concrete under tiles has been adopted. Although this system is not a novelty, it having been used by Mr. Nevill for over 25 years, it appears to be rarely employed in War Department works, and perhaps it deserves to be better known.

The best description that I can give is by reference to Mr. Nevill's specification, which he has kindly placed at my disposal: this reference is partial and brief, but further details can be readily obtained.

The plaster laths are first put on the inside of the rafters.

The outside of the rafters is then laid with single fir laths.

Rose nails, 2½-inch, are then driven into the back of each rafter, 4 inches apart, and left projecting 1 inch to form a key or holding for the concrete.

The concrete is made of 1 part Selenitic lime and Portland cement (mixed in proportion of 3 to 1) to 3 of ashes and 1 of sharp sand. Portland cement without the lime may be used if more convenient; the ashes may be coke-breeze or clean siftings from engine ashes, etc. The mortar thus made is laid on the laths, above the eaves lath, in long strips 1¼ inches thick, and carefully trowelled.

In 6 to 12 hours the concrete is sufficiently set to hold the tile pins, which may at this stage be pressed in by the thumb, or at a later stage a hammer may be used; the latter method is perhaps preferable, if there is any fear of the soft concrete dragging with the weight of the tiling.

It is necessary to sling a cradle over the ridge to support the workmen, the cradle resting of course on well-stuffed bags.

The ridge must be fixed as the work proceeds, and the tiling should be carried up from both sides of the ridge simultaneously, or nearly so.

The thickness of the concrete against chimneys, barge boards, etc., should be slightly increased to give the necessary tilt.

The process above described refers to tiling, but the system is equally applicable to a slated or an iron covered roof, and, with slight variations, to lead, copper, zinc, etc.

As regards weight there is little difference between the concrete and felted boards, the breeze being, as we all know, very light.

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The cost is of course an initial extra over plain tiling on laths, and in the case of slating the difference between concrete and rough boarding can readily be estimated. Mr. Nevill states that 15 shillings per square is a full approximate price for the concreting, and no additional strength is necessary either in the walls or roof timbers.

The advantages of the system are apparent almost without enumeration. The presence of an impervious sheet of concrete, which is bound to keep out snow, rain, and wind, and to ensure extra warmth in winter and coolness in summer, must be a great gain to the householder; and Mr. Nevill further remarks that it would be a great protection against the rapid spread of fire in a roof.

It is probable also that under this system there would be a considerable diminution in those small breakages which the slater produces when nailing, and which he usually conceals, much to the future trouble and expense of the property owner.

One great advantage must surely be in durability and cleanliness as compared with the results following the employment of felt and of various other materials, which in course of years become inoperative and, after becoming rotten themselves, communicate their rot to the boards and leave the slates loose and leaky.

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NOTES ON LOOPHOLES.

By Capt. H. O. Mance, d.s.o., R.E.

It is easy to dismiss the subject of loopholes with the remark that any fool can make them, provided he remembers that they must give a good view of the enemy, sufficient field of fire, a maximum of cover, ample scope for the necessary elevation and depression of the rifle, and be as invisible as possible. This is all very well, but a few attempts to make out of various materials the best possible loophole for a sited fire-trench will probably disclose the desirability of enquiring rather more fully into the application of the above principles.

It is not intended to imply that victory will invariably lie with the side employing the most efficient types of loopholes. Cases may arise where the kind of head cover or the entire absence of it are of comparatively small importance. But on the other hand, in situations where, for example, both sides are entrenched at close quarters (as was the case at Mafeking) an enormous advantage might (and did) accrue to that side which designed the most effective pattern of head cover. Besides, generally speaking, the more effective the defences are, the greater the number of men available for the counter-attack or striking force.

Reverting to the opening description of a loophole one is first struck with the fact that all the conditions except that of invisibility are very much influenced by the thickness of the material used necessary to keep out a bullet. The less this is, the easier it is to make the loophole conform to the conditions. In the case of a steel plate it is obvious that a very perfect type of loophole can be attained. Conversely a sandbag loophole with clayey soil, necessitating a thickness of about 5 feet to be bullet-proof, would be almost impracticable.

Yet earth will always be the principal and frequently the only material for head cover, and it behoves us to consider in what way its inherent disadvantages can be minimised. The following notes deal almost exclusively with sandbag loopholes, and no reference has been made to many better types of loopholes which can be made with other materials than earth.

Earth head-cover in its simplest form may be regarded as an increased height of parapet perforated at intervals by revetted

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apertures. Considering these apertures in plan the three well-known types A, B, and C in *Fig.* 1 suggest themselves.

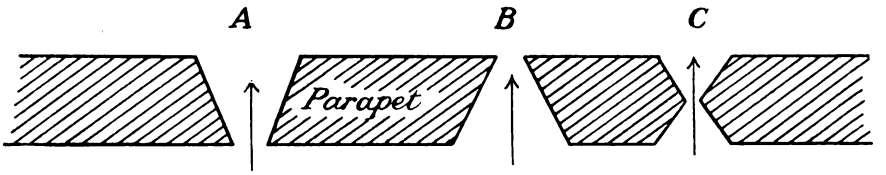

Fig. 1.—*Plan.*

Type A affords a better view of the enemy and requires less movement to fire from, but is more visible to the enemy. Type B is less visible to the enemy, but more trouble to see and fire through. Type C is a compromise between A and B; this pattern can be more easily adapted for a large field of fire.

Looking at these types from the point of view of protection from fire, it will be seen (*Figs.* 2, 3 and 4) in all the above cases that with the usual thickness of parapet, just enough to comfortably keep out bullets, shots coming from all directions P, Q, R, and S, except those indicated by P, are likely to penetrate the parapet and do damage beyond.

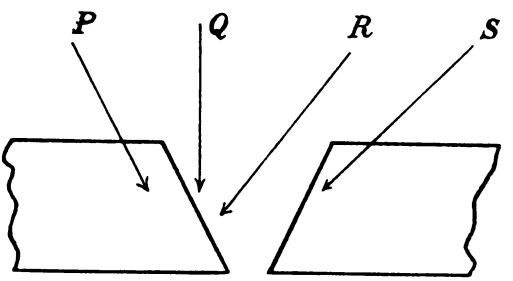

Fig. 2.—*Plan. Type A.*

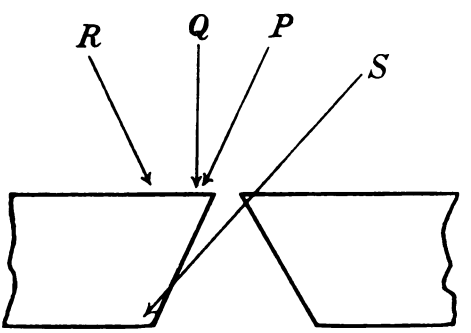

Fig. 3.—*Plan. Type B.*

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It can also be seen that nothing is gained by thickening the parapet in the case of a single loophole of A or B type ; but a great deal is gained in type C, as bullets from R and S can then be kept out. The width of the danger zone for bullets coming in the direction Q is least in type C for the same field of fire.

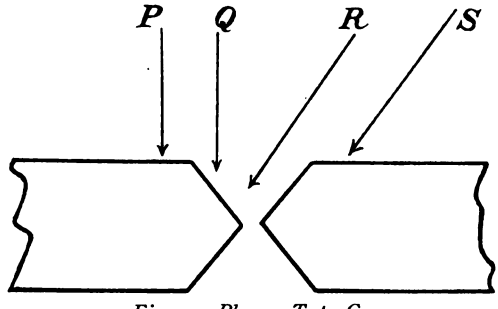

Fig. 4.—Plan. Type C.

From the above, the best type of earth loophole appears to be **X** shape in plan, the parapet being $\sqrt{2}$ times the proof thickness, assuming for example that a field of fire of 90° is desired.

It may here be pointed out that, in order to take full advantage of the increased range of modern rifles, either loopholes must be constructed with a wide field of fire or else alternative loopholes must be constructed. The former is worth trying for as being more convenient and also necessitating less labour in digging trenches. Here we are reminded that we must not confine ourselves to single loopholes, for loopholes will, as a rule, be made at minimum intervals along the parapet (*Figs.* 5, 6 and 7).

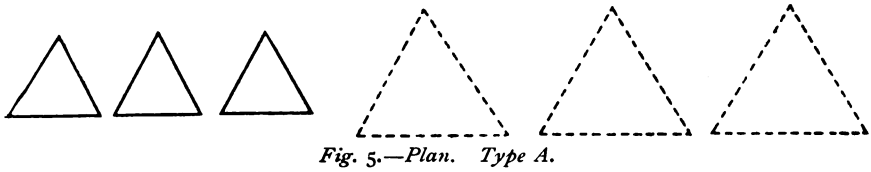

Fig. 5.—Plan. Type A.

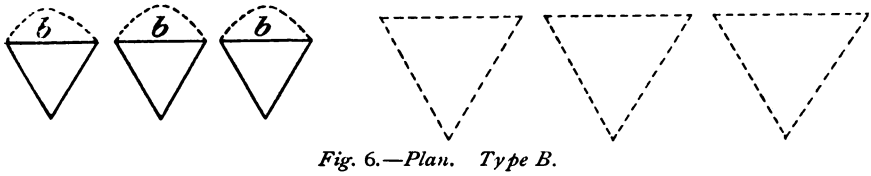

Fig. 6.—Plan. Type B.

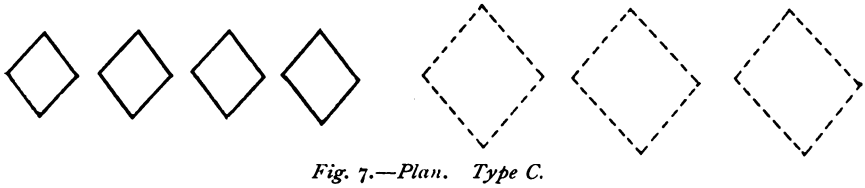

Fig. 7.—Plan. Type C.

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Comparing types A, B, and C, it is evident that they are almost equally useless for keeping out bullets, unless the thickness of the parapet from front to rear is made a good deal greater than the minimum thickness proof against bullets. This thickening of the parapet results in the loopholes being spaced wider apart, and for any given field of fire the C type takes up less room besides affording more protection. The practice of putting earth between the front faces of loopholes of the B type (as at *bb*, *Fig.* 6) merely converts this loophole to one of the C type.

The head-cover need not be the full thickness of the loopholes, the proof thickness being all that is required. In the C type loophole the span of the head-cover supports is less than in either the A or B types, thus facilitating construction.

A splay of 90° has been mentioned above. This amount would be impracticable in a sandbag earth loophole except of the C type; in the latter it is not only practicable but easier to construct, as the sandbags can be laid square.

Fig. 8 shows the proposed type of loophole in ordinary soil. The corners AA can be done away with if preferred by tucking in that portion of the sandbags. Such a loophole requires careful construction if the centre opening is to be only 4″; with unskilled troops 6″ would perhaps be better. The theoretical minimum distance apart of these loopholes is 3′ 10″, but in practice it works out to about 4′ 8″.

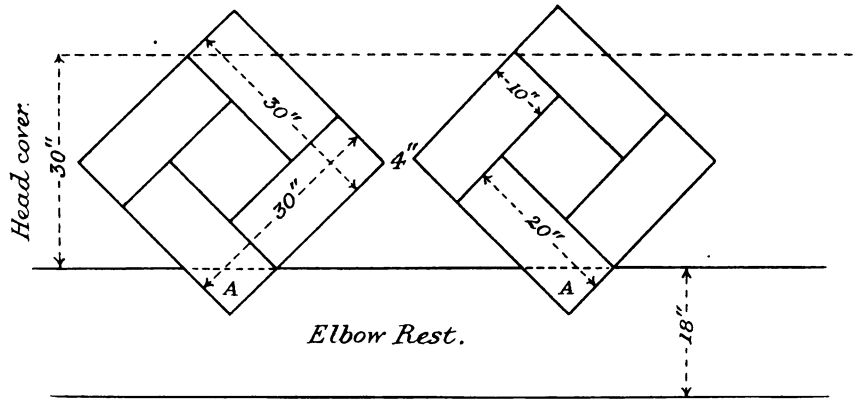

Fig 8.—*Plan. Sandbag Loophole.*

Before passing from the consideration of earth loopholes in plan, it may be mentioned that the protection obtained by an ordinary earth loophole can be much improved by placing a large movable stone, a piece of iron plate, or some other proof substance in that part of the loophole not in immediate use. A loophole as shown in *Fig.* 9 has been suggested if such substances are available.

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This pattern gives a wide field of fire and a partially masked opening.

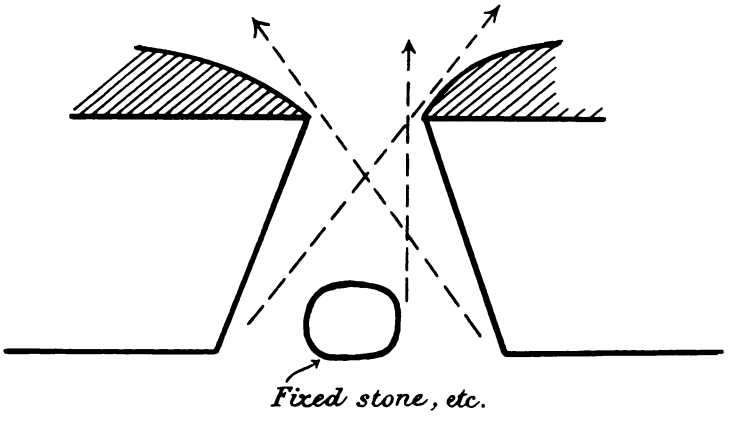

Fig. 9.

Let us now examine how the section of an earth loophole along the line of fire affects its efficiency. *Fig.* 10 shows a section through a simple type of earth loophole on a low parapet on level ground with a height of opening in front and in rear of 10 in. On level ground no depression of the rifle has to be provided for, so earth could be filled in as shown (*abc*, *Fig.* 11) without interfering with the free use of the rifle, the slope *ac* depending on the maximum elevation required. If now still more earth (*a*, *b*, *e*, *d*) is added to make this raised portion of the parapet bullet-proof, the vulnerable height of the loophole is at once reduced to about 4 in., without any compensating disadvantages and with the additional advantage of being less conspicuous. It must be noted that, as the parapet is thus raised 6 in., the trench must be made 6 in. shallower or the original parapet on which the loophole is built 6 in. lower, preferably

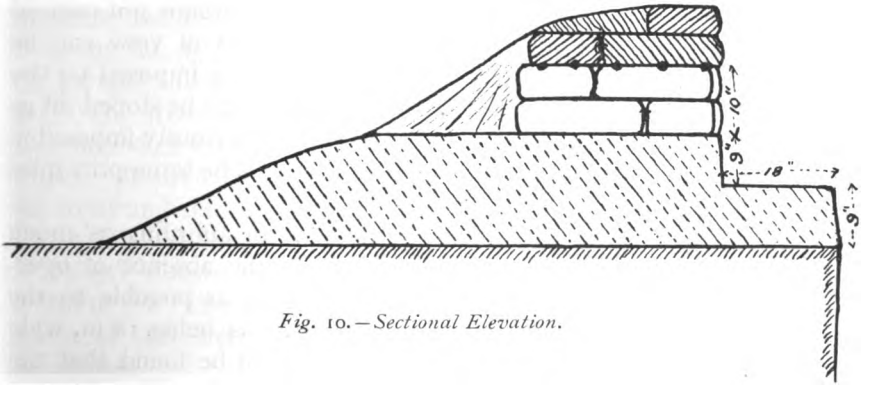

Fig. 10.—*Sectional Elevation.*

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the latter as otherwise the trench will have to be widened to obtain the necessary extra earth.

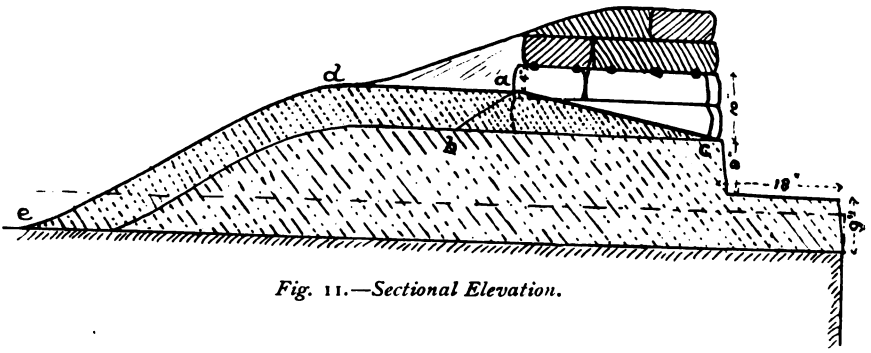

Fig. 11.—*Sectional Elevation.*

If the trench is sited for firing downhill, before starting to build the loophole, the top of the parapet must be sloped off to the lowest line of fire, and the procedure is the same as before (*Fig.* 12). The height of the loophole before filling in must be increased to three sandbags, if a large vertical arc of fire is required.

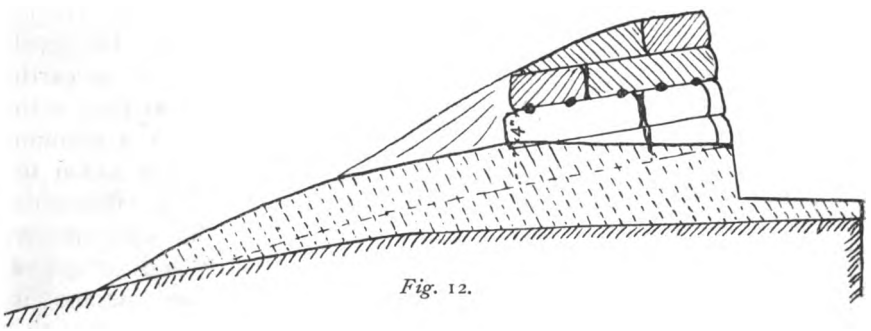

Fig. 12.

When a parapet is first constructed without head-cover on an elevated position, it is not infrequently the case in practice that the superior slope is made too level. The error is perhaps not noticed at first, as by slightly raising the eye a good field of view can be obtained. But where loopholes are added a limit is imposed on the height the eye can be raised, and the parapet has to be sloped off as shown in *Fig.* 13. Under the circumstances it is obviously impossible to improve the cover to any appreciable extent. The same principles apply to parapets sited for up-hill fire.

Great stress is now laid on the importance of affording as much protection as possible from searching fire. In the absence of overhead cover the next best plan is to get as close as possible to the parapet. The ordinary elbow rest is laid down as being 18 in. wide and 9 in. high; but in nine cases out of ten it will be found that the

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rest has been made at least 6 inches wider than this, so that the loophole has the appearance of being out of reach. Special attention must therefore be paid to checking this fault ; and when cover from searching fire is specially important, the elbow rest can with advantage be made narrower, say 1 ft., in which case it must also be made correspondingly higher or it will be impossible to use it.

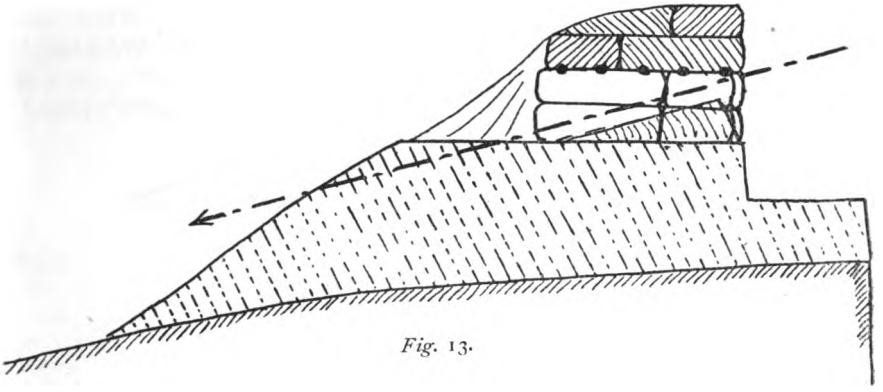

Fig. 13.

As regards concealment, this depends entirely on the nature of the ground surface and the time available. A sandbag loophole is not easily concealed, but it is surprising what can be done under favourable circumstances such as in heather, bracken, or long grass. A few small bushes or herbs planted in front of a loophole, and trimmed so as not to interfere with the view, are a great help in masking the shadow of the loophole and the aperture itself. The latter will nearly always be conspicuous unless masked in this way, or by having some sort of curtain on the inner face. Care must be taken not to transplant coarse weeds which are likely to die and change colour. If the position is to be held for more than one day, most plants except heather will probably require watering until they have taken root again.

It is no use concealing the loopholes if the parapet itself is conspicuous, and the most carefully assimilated parapets are often given away by the appearance of a shaded slope. To guard against this the parapet should be as low as possible, with the superior slope very flat. The free use of comparatively conspicuous dummy parapets and loopholes will also draw attention away from the better concealed works. If circumstances admit, the trenches should be viewed from the front and flanks of the line of the enemy's expected attack and under different conditions of light, before they are finally "passed."

Shingle Loopholes.—If there is a supply of gravel, shingle, or road metal in the vicinity of a defensive position, advantage may well be taken of this fact to make loopholes as follows instead of earth loopholes.

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Place one sandbag inside another and fill the inside one with the above shingle, etc. Three such double sandbags will make a loophole, the parapet being completed with single sandbags also filled with shingle.

If higher head-cover is desired, stability may be assured by extra sandbags filled with earth, as shown dotted in *Figs.* 14, 15 and 16.

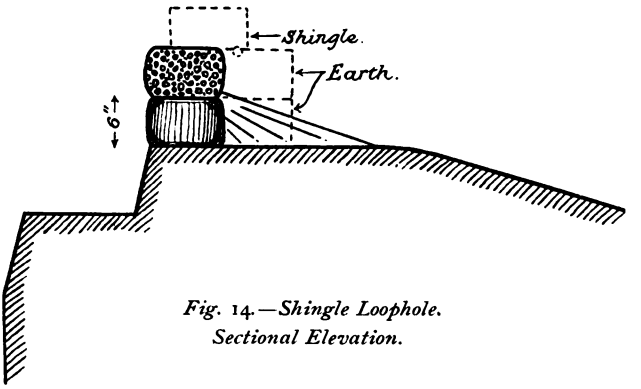

Fig. 14.—*Shingle Loophole.*
Sectional Elevation.

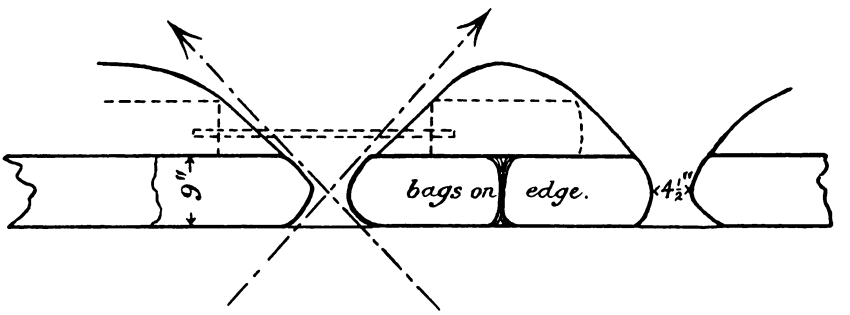

Fig. 15.—*Shingle Loophole.*
Plan.

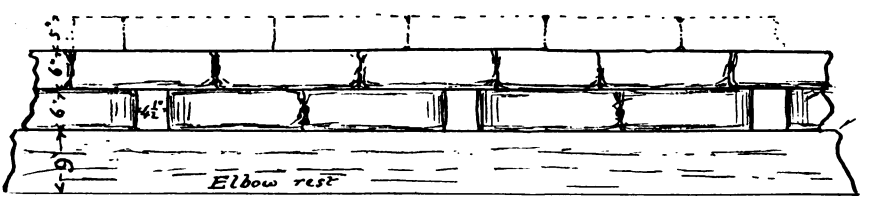

Fig. 16.—*Shingle Loophole.*
Rear Elevation.

The sandbags forming the loophole parapet are placed *on edge* and stamped out until the loophole opening is curved (as shown in plan) and the bag is about 9″ wide and 6″ high. This loophole, which requires comparatively few sandbags, is absolutely proof to within

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one inch of the edge all round ; and it is almost impossible so to hit the bag on the edge as to cause a serious split.

As a refinement, a little earth might be mixed with a very clean sharp shingle when the latter is used, as such shingle used alone is naturally slightly more liable to cut the bag.

Metal Loopholes.—At Mafeking, the besieged employed a very serviceable type of loophole (*Fig.* 17), an iron plate about 3 ft. × 1 ft. 3 in. and ½ in. thick, bent at right angles and with a small rectangular hole at the angle. These loopholes were embedded into the parapet and must have been most comforting during the fighting at about 200 yds. range. Very few types of loophole would stand the twenty-six bullets which struck one of these plates.

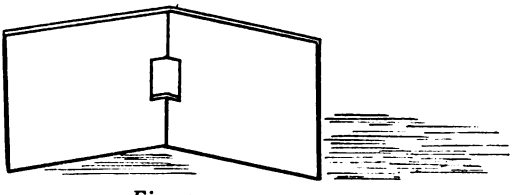

Fig. 17.

The theoretically perfect loophole, which, however, for various practical reasons is hardly within the range of practical utility, even to the keenest Sapper, would be a combination of a pivoted steel plate *a* and a fixed plate *b*.

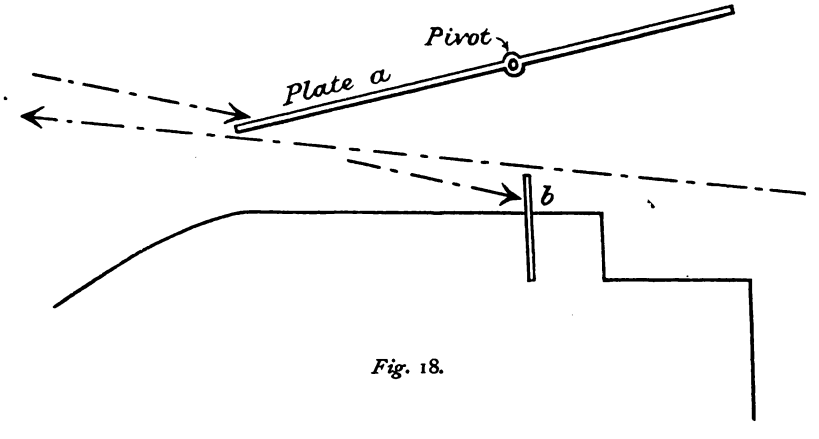

Fig. 18.

The plate *a* must be canted just enough for the bullet to leave at the required angle of elevation for the enemy's firing line. The angle of descent at any range being greater than the elevation, the defenders would be immune !

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THE BATTLE OF HASTINGS.
14*th* *OCTOBER*, 1066.

By MAJOR-GEN. E. RENOUARD JAMES, LATE R.E.

IT was my lot, while serving as an officer of the Ordnance Survey, 37 years ago, to accompany the late Mr. E. A. Freeman, M.A., the historian of the Norman Conquest, to the field of Hastings, and to have the privilege of assisting in making a plan of the battle ground. I thus gained an elementary knowledge of the incidents of the great victory won by William of Normandy on which I had previously only the limited ideas of any schoolboy.

The interest aroused in my mind was sufficient to cause me to study the battle from a military point of view; and at the earliest stage of my enquiries it became evident that gross misconceptions abound in the popular descriptions. In the following notes, in the compilation of which I have to acknowledge much kind assistance from the Hon. F. H. Baring, it is my aim to correct the prevalent errors.

A very detailed account of the Conquest of England by the Duke of Normandy is preserved in the famous *Roman de Rou*, written in archaic Norman-French, about a century after the events described, by Wace, a canon of the cathedral of Bayeux: English students are familiar with this work by translations, notably that by Edgar Taylor, published in 1837. A graphic representation of the same events exists in the celebrated Bayeux tapestry, the origin of which is uncertain, though it is not disputed that it dates from the 11th century: it is beautifully exhibited at Bayeux, and a traveller in Normandy should on no account fail to make an inspection of it. Although not absolutely in accord, both of these authorities may be accepted as derived from trustworthy sources, if they be not, indeed, based on information given by eye-witnesses. In endeavouring to reconcile and explain the points in which the Romance and the Tapestry differ, modern writers rely much on the records of contemporary chroniclers, among which are those of William of Poitiers, Orderic Vitalis, Guy of Amiens, William of Jumieges, the chronicles of Battle Abbey, etc. But it is unfortunate that the whole of these records are, more or less, biased on the Norman side, while there are very few good authorities on the part of England: this is not to be wondered at, for it was not likely that men would record their own defeat and humiliation.

The principal modern English authority is undoubtedly Freeman, whose great work was published in 1869. I assisted him, as I have

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said, in the topographical work of the only original large-scale plan of the battlefield which has been produced ; it may be found in Volume III. of *The Norman Conquest.* As to my share in it, I can only vouch for the comparative topographical accuracy (the Ordnance 6-inch map did not then exist), but disclaim all responsibility for the way in which the position of Harold and the details of the battle are shown. The appearance of the book at once provoked a storm of criticism, which has not abated yet, and among the writers on the subject may be named Mr. Round, Sir James Ramsay (in *The Foundations of England*, 1898), Mr. C. W. Oman (in *The Art of War in the Middle Ages*, 1898), and, recently, the Hon. F. H. Baring. A writer preceding Freeman was Creasy (in *The Fifteen Decisive Battles of the World*, 1851), whose account of the battle is in the main a mere series of extracts from the *Roman de Rou*, with little of definite military value, and need only be referred to by saying it is full of the ordinary popular errors.

If the words of the old authorities are weighed carefully, and allowed their relative credibility, views held by those who have only studied the subject superficially must soon undergo change. We have been too ready, hitherto, to accept grossly exaggerated numbers in estimating the strength of the opposing armies. Freeman seems to have fallen into the trap like the rest ; for although he guarded himself against giving an opinion as to Harold's numbers, it is plain that, in marking the defensive position on the map at so great a length, he sought to provide room for the large number popularly believed to have constituted the English army. It would not have been proper for me, in my profound ignorance in 1869, to question his accuracy ; but a recent examination of the ground, made with the new 6-inch map in my hand, has convinced me (and would, I think, have the same effect on any military student) of the inaccuracy of Freeman's conception. In accepting the belief that Harold's army was so large, it was necessary, consequently, to admit a proportionate increase in William's ; and as the old chroniclers, from whichever side they wrote, exaggerated the numbers on the other side, a mass of error has been perpetuated. It is easy to prove that a very large reduction in the numbers must be made.

Another controversial point, which remains unsettled still, is the nature of the line of obstacles erected by Harold—if obstacles there were at all. While some authorities maintain that the position was covered by a strong palisade and ditch, others contest that there were no obstacles of any sort beyond the shields of the defenders. After the evidence on this point has been stated, it is hoped the readers of these notes will offer opinions which will assist in settling this vexed question.

Other points for consideration are the movements of the forces on either side, and the identity of the sites at which the incidents of the

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battle occurred; but these need only be referred to in their place in the narrative.

Following the ancient authorities generally, but quoting from them only when it becomes necessary to compare their evidence, let us make a brief retrospect of the political events which led to the invasion of England. In a genealogical table, to be found in the translation of the *Roman de Rou*, it is shown that William of Normandy claimed cousinship with Edward the Confessor, and, the latter being childless, saw an opportunity of gaining the succession to the English throne. He crossed to England on a visit in 1051, and was received with great honour by Edward. The King had recently quarrelled with Earl Godwin, his father-in-law, who had delivered a son and a nephew to him as hostages for his future behaviour. William begged to have their custody, and sent them to Normandy, with the intention in his mind of retaining them as prisoners in order to prevent their becoming his rivals. On his return to his own dukedom he set up the pretension that Edward had nominated him as heir to the throne of England.

At this stage of the history we are introduced to Harold, who claimed kinship with Edward through Canute, the first husband of the Queen, and is described by old Wace as a noble vassal, the most powerful chief in all England. Harold obtained the King's permission to go to Normandy and bring the captives back; with his mission the Bayeux tapestry opens. He was cast up on the coast of France by a storm, and fell into the hands of Guy, Count of Ponthieu, who gave him up to William as a prisoner. He was entertained with the highest honours, and accompanied the Duke on warlike expeditions against the Bretons, in the course of which he was knighted by William on the battlefield. He was cajoled into making a promise to deliver England to William on the death of Edward, and he was compelled to ratify the same by oath, at a council assembled at Bayeux, before he was permitted to return to England.

In Wace's romantic verse we read that Edward, on his death bed, denied that he had promised the kingdom to any foreigner, and, in the presence of his councillors, formally nominated Harold as his successor to the throne. Another Norman authority, Benoit de Saint More, declares that this story was of Harold's invention, and that in reality he had no title but his usurpation. Whatever may be the truth, Harold seems beyond doubt to have been the King of the people's choice; and unquestionably to have been preferred to the Duke of Normandy. On becoming King he at once repudiated the oath forced from him at Bayeux under terror and false representations as to Edward's alleged promise; and William then resolved on the invasion of England to enforce his claim.

The Duke called his barons and prelates into council, and after much heated discussion induced them to promise their assistance. A

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summary of the names of those who were willing to help may be found in the pages of Freeman, who, quoting from various sources, states that 812 ships, with as many knights and men-at-arms as they would carry, were promised; according to Wace, however, the number seems to have been only 752. The King of France, who thought the Duke of Normandy, his nominal subject, was too powerful already, refused his aid; while William's brother-in-law, the Count of Flanders, not satisfied with the conditions proposed by the Duke for the division of the spoil, was only persuaded to promise help faint-heartedly. By clever diplomacy William was more successful with the Pope, who sent him a standard, and consented to his conquering England to hold the land from St. Peter. While the invasion was under discussion a comet appeared in the sky, and was thought such a favourable omen that superstition brought allies from every side; from Brittany, Picardy, Maine, Provence, Flanders, and even, it is said, from Italy. Timber and materials were hastily collected in all the ports of Normandy, and one summer and autumn were spent in building ships and training men. Freeman states that the very trees had not been felled: for this there seems no warrant beyond a representation on the tapestry of a woodman cutting down a tree. But, undoubtedly, the ships were built hurriedly, and it was not possible for them to be of any considerable size; we may suppose that the largest were no bigger than the fishing boats on the north coast of France at the present day. Wace states that he heard his father say the number of ships which sailed for England was "seven hundred less four" (which allows of a reasonable discount from the 752 promised), and that small boats and skiffs carried arms and stores. He had "seen it written, but did not know how true it was, that in all there were three thousand vessels bearing masts and sails"; and Benoit de Saint More says there were three thousand keels (nefs) at least.

These figures, doubtless, are mere guesses made to include the small skiffs which were towed, and in estimating the number of boats which actually carried men and horses we must be limited to the 696 of Wace as quite a maximum. The largest ships represented on the tapestry have only one mast and sail; on one 13 shields in a row indicate as many cross seats, and supposing 4 armed men on each seat we get 52 foot soldiers as the boat's load. In another boat 3 horses with 2 seamen are shown, and in a smaller boat, with rowers, only 5 soldiers. If we analyse the list of donors referred to before, we have another method by which we can form an estimate of the ship-loads. One exceptionally large ship—that of Remigius—was for 20 knights, but those furnished by the Abbot of St. Ouen were, on an average, for 5 knights only; while, in other cases given, the ratio varies from $3\frac{1}{3}$ to $1\frac{1}{3}$ per ship. Three knights per ship, in addition to their esquires, and as many men-at-arms, seems, then, to be as high an estimate as we are warranted in making for the general average

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capacity of each horse-carrying ship. As regards the infantry, although a single boat may have carried 50 men, another was for 5 only, and we cannot calculate the average loads as more than 25 men. Finally, if we suppose that not more than 400 of the large boats carried horses, we complete speculative data from which an estimate of the strength of the expeditionary force may be made, as follows :—

400 ships, each with 9 men and their horses...	3,600 cavalry.
296 ships, each with 25 men, the heavy-armed infantry and bowmen	7,400 infantry.
Total	11,000 men.

While this result might easily be varied by using ingenuity in manipulating the speculative data, it may be noted that it agrees fairly with the opinion of Sir James Ramsay that 10,000 men was the maximum number brought across the channel. By no stretch of the figures, however, can we, by a similar method of reasoning, approach near to the 60,000 commonly believed in.

The force which assembled in Normandy is variously reported by the chroniclers; by William of Poitiers it is put at 60,000, and even more, while the Chronicle of St. Maxentius has it at 14,000. But whichever of these is nearest the truth, neither one statement nor the other is evidence of the number of men who embarked. William of Poitiers, in mentioning a messenger sent to William by Harold after the crossing had been effected, makes the Conqueror say that, if he had only 10,000 men such as the 60,000 he had with him, he would go on. We can see plainly that this was mere bragging, and it need not make us change our opinion that the force was not much in excess of 10,000; for the messenger, on his side, had just boasted that Harold had 100,000 men at his back, which William knew well enough to be a gross exaggeration. The old chronicler Wace tells us Harold did not fail for lack of numbers, but that in reality there was about man for man in the opposing armies; which is probably quite true, but with the numbers on both sides diminished, as we see they must be.

For comparison's sake some facts about later invasions are worth noting. According to the best authorities, Edward III. never shipped 10,000 men across the channel; and Henry V., and also Edward IV., only just succeeded in making up such a number. Three statements in Eccleston's Antiquities are as follows :—in 1254, one ship capable of transporting 30 men is spoken of as being of extraordinary magnitude; in 1346, in the expedition to Calais, there were 783 ships, which could only carry 20 men each; and, as late as 1360, three centuries after Hastings, the art of shipbuilding had advanced so little that the largest in an order given was only for 44 men-at-arms. Do

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not these facts alone compel us to discredit the exaggerations about the Norman Conquest ?

William's preparations were known in England, and to oppose them a fleet was assembled in the Solent, opposite Dives (near Caen) where the Norman ships were collecting. A naval expedition under a Norwegian chief, Tostig, supported by William, harried the southern coast of England, but did not achieve any substantial success. It had, however, the effect of drawing the English ships away ; some of them went northwards, some to the estuary of the Thames, and the larger part became ineffective and were disbanded ; their absence from the south coast permitted the fleet of William to leave Dives. The Norman ships, driven by westerly gales, took refuge in and about St. Valery, at the mouth of the Somme ; this seemed at first to be a misfortune ; but in reality it was an advantage, for the channel being almost at its narrowest point at St. Valery, the invasion of England became the more easy.

The fleet waited tediously for a fair wind, and had this not occurred auspiciously it is doubtful if success would have attended the expedition. Very fortunately for William, such a wind came at the time Harold was in the north of England. The passage across the channel was made in one night and without accident, there being just enough wind to propel the ships in a direct course.

William's army landed on the Sussex coast, early on the 28th September, if Wace be correct, rather to the west of Pevensey Bay, quite without opposition. The boats were run up on the beach, just as craft of like size may be seen at Hastings at the present day. But I think it is an error to suppose that the ships were destroyed, as some accounts state ; for it seems more probable that they followed the march of the army eastward, and eventually entered the inlets of Winchelsea and Rye, which were used as a naval base later.

The Norman bowmen waded ashore as the ships grounded, and at once extended to the front to cover the disembarkation of the cavalry, meeting with very little opposition. The cavalry, without their armour, landed next ; and were followed by artizans, who erected a defensive work near the shore with materials previously prepared to fit together. The infantry then landed slowly ; and on the third day the entire force was ready to move to Hastings, where another defensive work was erected, the army being bivouacked, probably, along the heights north of the town. Such was the Norman position when, sixteen days after the landing, intelligence was received by William of the rapid approach of Harold from London.

The sun rose on the 14th October at 6.20 a.m. ; but lunar tables show there was a two-thirds waning moon, still high in the sky at dawn, and it is recorded that the morning was unusually light for the season. The army was called hastily to arms, and was in movement at an early hour. As the advanced posts were, probably,

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somewhere on the main ridge between Ore and Baldslow, the distance to the front of Harold's position was not five miles; and the line of march followed the watershed line separating two distinct basins, which was then, as it is still, the main road to London. For the whole distance a narrow, nearly level, heathy ridge, from which the slopes on either hand fell quickly away, was followed. The hillsides were largely clothed with woods, and the bottoms of the valleys were marshy. In the distant prospects (which are of well-known beauty), although the trees might conceal scattered scouts and archers, a soldier's eye could search the front so easily that the presence of an enemy in force would soon be detected. The Normans were able, therefore, to march quickly with little risk of encountering resistance until the English main position should be reached.

On arriving at Telham Hill, William (according to all accounts) received the reports of his scouts, and ordered a halt on a site called 'Hecheland' in the Abbey Chronicle, where its position is so precisely described that the Hon. F. H. Baring has been able to identify it closely, at an altitude of 462 feet above sea level, on Telham Hill, at exactly two miles from the English line at Battle. The place may be traced by referring to the 1-inch Ordnance map, where it will be found close to the name 'Blackhorse hill' in small print. Local tradition, for which no foundation has been found, has wrongly fixed the halting place at the site, a mile nearer Battle, on which stands a windmill.

The exact position of the halt is, however, of less importance than the information we gain on the use of armour in 1066. According to the Abbey Chronicle, William and his chief barons had ridden lightly equipped until the halt, when they donned their armour; but this is at variance with both the Romance and the Tapestry, in which they are represented as fully armed on starting from Hastings. The Chronicle may be accepted as more likely to be correct, for it is reasonable to suppose that the fatigue of wearing armour was not customarily suffered until the latest moment before a battle. The armour worn was not, however, as heavy as that of a later date, as it consisted of the hauberk, or chain-mail shirt, as the principal body covering, and not the suit of plate armour, which was not yet in general use; the head was protected by an iron cap with nasal frontals, and the legs were guarded with metal plates. In one account William Fitz-Osbern and his horse are described as wearing complete plate armour; but this is believed to be an anachronism, as there is no authority for the horses in 1066 having worn any armour at all, and they are represented without it on the Tapestry. An incident during the battle leads us to think that William the Conqueror wore a helmet with a close visor; that he wore a mailed shirt we have evidence in the anecdote, repeated by different authorities, that he put on his hauberk, at first, backwards, adroitly using the incident as a good augury for his success.

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On learning of the position taken up by Harold, the Duke immediately ordered his force to advance in three divisions. It was probably a surprise to him that Harold had already posted his army strongly; for he had hoped to fall on the English on the march, and by the help of his cavalry and superior discipline to defeat them easily.

The road, which continued to follow the open crest until it approached the site of the modern village of Battle, fell from the height of over 400 feet above the sea until a neck of ground at an altitude of 219 feet was reached. This point is not, as most writers have said, in the valley, but only at a depression on the watershed line. It is important to note this, for the hold on the crest line gave William an important advantage in case of a counter-attack; and, in fact, such was its actual use during the battle. (Reference to the accurately contoured plan accompanying this paper will make this clear). When William reached the neck, where he was out of archery range from the English line, which he now saw extended across his front, he at once ordered a deployment of his force to the right and left.

The dispositions made for attack and defence will be better understood if the movements of Harold, from the time the Norman fleet sailed from Dives until his own arrival on the battle ground, are first traced briefly. After his raid along the south coast had caused the dispersion of the English ships, the Norwegian chief, Tostig, proceeded to support the descent on the east coast made by Harold Hardrada, of which it is unnecessary to speak at length. The King of England hastened northwards to repel this invasion; and concerning the campaign which followed it is sufficient to say that Harold Hardrada suffered a complete and decisive defeat at the battle of Stamford Bridge, fought on the 25th September. The King, it is said, was at York on the 1st October celebrating this victory, when a horseman, who had come from Sussex with all possible speed, brought the news of the landing of William at Pevensey Bay on the 28th September.

Not an hour was to be lost, and Harold returned to London as quickly as he could ride. The bulk of his famous bodyguard had been with him in the north, and he was compelled to wait some days in London, fretting at the delay, while they, or some portion of them, were marching southwards. In the meanwhile half-trained levies were collected hastily, and the manhood of southern England flocked to the standard in Sussex. Harold himself left London on the 12th October, and reached the position on which he made his stand on the 13th. The bodyguard also arrived from York, having marched 250 miles in 11 days; if they were the very men who had fought at Stamford Bridge, it was a wonderful feat. Some writers have supposed that Harold hoped to surprise William by a night attack; but Oman's opinion that the position was deliberately selected is more likely the correct view.

There is some evidence to show that the ancient name of the site

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was 'Santlache'; and that 'Senlac,' the name by which the battle is known in France, is a corruption of the old Norman writers from this, possibly intended to denote a pool of blood. We speak of it in England as 'the Battle of Hastings,' and it is therefore so designated on the heading of this article.

From a range of low hills, at a general altitude of 300 feet above the sea, mainly covered with forest at the time of the Conquest, the road from London descended upon, and followed the crest of, a narrow ridge, dividing valleys on either side, which is now marked by the main street of Battle. At its southern end the ridge broadens out in the form of a tongue of ground, running east and west and nearly square to the direction of William's line of march; this was the fine position chosen by Harold. It seems to have been almost bare of trees, as the chroniclers only note one;—a "hoar apple tree." The probable line occupied has been the subject of the most careful consideration on the actual ground by Mr. Baring and myself, and the opinion we have formed is that the defensive position was (as shown on the plan) about 700 yards long and nearly level. On Freeman's plan (Vol. III. of *The Norman Conquest*) it is given a length of 1,650 yards, Harold's left being made to run down the hill in a dangerous manner, this extension being evidently adopted to provide room for the number of men,—20,000 to 25,000—usually stated to have been placed along the ridge. The men are stated to have been in ten, or more, ranks, crowded together ('conglobati' being the word used to express their formation); and if the length of the line be limited, as we say it must have been, the total number of men who could be packed on the ridge would be 9,900. To this number we may reasonably add 1,000 on the isthmus in rear, and thus we get an aggregate of 10,900. Possibly, also, there was a horde of peasants in the woods at the back; but these were a useless encumbrance, and doubtless vanished like a summer cloud when the English defeat became evident.

The slopes from the position fell quickly away towards the front. The gradients are as follows:—along the centre, 1 in 15; on the left flank, 1 in 22; and on the right, 1 in 33; the slopes at the extremities of the line bend quickly backwards, and become 1 in 8 on the right rear, and 1 in 4 on the left rear. On both sides of the narrow isthmus the slopes continue steep, and it is evident that the position could only be attacked in front. Flank attacks were but little practised in 1066, and Harold did not think of one as possible. He appears, rather, to have looked on the position as an impregnable redoubt, believing firmly in the ability of his housekarls to withstand any possible attack which could be made. Retreat did not enter his mind; if it had done so, he could have prepared an excellent position for a second stand on the hill at the back; but we shall see that, when defeat came, the retreat was a disorderly rout.

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Let us pause to consider how far the number we have arrived at is in accord with what is known of the military power of England in the 11th century. The statement of Benoit de St. More that Harold had 100,000 men at his back may be dismissed as a Norman fiction, or, if he quoted from an English source, as mere boasting. The entire population of the country, exclusive of the unsettled areas, did not exceed one million; and the maximum number of male adults of suitable age for public service amounted at most to 48,770, the number said to have been the constituted military force of the kingdom under the Anglo-Saxon rulers (Hume, Vol. I.). This total may be understood as a paper estimate of a mere militia force, which in ordinary times would have to be divided by four, at least, to reach the number likely to be called out at once. The duty to be done included the preservation of order, the repair of roads and bridges, and (not the least in importance) the protection of game. A large deduction must be made in calculating the number it would be possible to assemble in an emergency, at one place, for actual military operations. Considering these points carefully, the estimate of 10,900 men present on Harold's position seems as large an one as we can reasonably make.

Some, if not all, of the housekarls who had been with Harold in Yorkshire had joined the main body of them at Battle, and we have seen how great was the King's impatience while he awaited the arrival of this splendid contingent. The whole of them present did not number more than 3,000, or about one-third of the force on the position; and apparently they were the only thoroughly trained and disciplined body in the English army. They were entrusted with the defence of the Standard, which at first was planted on the highest ground almost in the centre of the line, a hundred yards or so to the north-west of the site of the ruins of the Abbey Church (subsequently founded by William), to which site it was probably moved before the final stage of the battle.

The housekarls are described as having been equipped with short, closely-fitting leather jerkins, on which iron rings were sewn; they wore the hair long, and their heads were covered by steel caps with nasal pieces, long leather flaps falling over the shoulders; they were shod with sandals, and their legs were bound with thongs. They carried long leather shields, so made as to rest on the ground and lock together, forming a sort of wall strong enough to stop arrows in flight. Among their offensive weapons the chief was the long two-handed axe, with which a horse and his rider could be cut down at a stroke, but which had the double disadvantage that it was necessary to open the shield wall to use it, and that its recovery after the blow was struck was so difficult that its holder, for the moment, was completely exposed. It was necessary, consequently, for a proportion of the men to have other arms—javelins to throw, short swords, and

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keen-edged bills—for use until the shields were relocked. The house-karls were noted for their perfect drill in using their offensive and defensive weapons together to advantage.

The light-armed auxiliaries, who were posted along the front and on the flanks, wore, for the greater part, plain leather jerkins, but many were in the ordinary costume of the peasantry. Their arms were various—spears, short axes, bills, scythes, javelins to throw, slings to hurl stones, and even stone hammers. Only a few wore chain-covered shirts, or had the long axe, but very generally they carried some sort of small shield. They had long hair, and their heads were covered with leather caps. They were not well-trained or disciplined, but their bravery is indisputable.

The English had no cavalry and very few bowmen. The few horses which belonged to the leaders were sent to the rear, and, from the King downwards, all fought on foot. The King and his two brothers took up their position near the Standard, on which was Harold's device of a fighting man.

I come now to the point upon which there is the greatest difference of opinion,—the nature of the obstacles, if any existed, which covered the front of the position. In the *Roman de Rou*, written by Wace, a canon of Bayeux, a century after the battle, there is an elaborate description of a palisade and fosse; but no indication of an artificial obstacle appears on the Tapestry, nor does William of Poitiers, a contemporary authority, mention the existence of one. In spite of its minutiæ, the negative evidence of the Tapestry may be set aside, if we regard its design as merely decorative and as one in which, for simplicity's sake, much detail was evidently suppressed. It is noteworthy that although the Tapestry is thought to have been founded on sketches by Odo, Bishop of Bayeux, who was personally distinguished as a combatant at the battle, no allusion should be made to it in the Romance; from which it might be argued that Wace, who possibly worked from manuscript notes left by Odo, purposely ignored the work of women as being, at the best, derived from the same information. On the other hand, although William of Poitiers is said to have been a priest in the suite of the Conqueror, there is no proof that he was on the battlefield himself, and he may have compiled his account from the reports of others. The question of the obstacle thus resolves itself, in great measure, into a consideration of the relative credibility of Wace and William of Poitiers; and it is difficult to conceive that the former absolutely invented his circumstantial statement.

According to the *Roman de Rou*, the position was guarded in three parts, with openings between them. In front of the defenders were raised barricades of ash and other trees, closely joined together. This view is adopted by Freeman (*The Norman Conquest*, Vol. III.), as well as by Oman (*Art of War in the Middle Ages*, p. 153), but is

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not accepted by most other writers. Oman points out that a hurdle fence with a ditch in front was a Danish device used in England 200 years before, and thinks that the hurdles at Hastings were not more than four feet high. If he is right, we might go a step further, and suggest that, as the materials were close at hand and plentiful, the words which are translated "trunks of ashes and other trees" refer possibly to something of the nature of an abattis in front of the hurdle revetment. As the attacks were spread over eight or nine hours, something more than the shield-wall would seem to be required to maintain such a desperate resistance. The question for consideration, then, is what the obstacle really was?

Wace declares the English spent the night before the battle in carousing, and gives some picturesque information about the toasts drunk; he also states that the Normans were engaged in religious exercises. But this must be taken as mere rhetoric, if we accept the fact that the Normans were suddenly called to arms, on the morning of the battle, seven miles away, and that the English had hastily occupied the position and were hard at work. Another statement, also unconfirmed, is that Harold and Gurth rode to the Norman camp to parley; it seems more probable, as the King was accused of treachery and perjury, that he would not dare to run the risk of being detained as a prisoner. The truth would seem to be that the march from London was so hasty that the King only reached the position late on the 13th, and at once ordered such defensive measures as were possible of execution in the short time available.

Soon after it was fully light the English perceived the enemy pouring down the slopes of Telham in orderly formation. At this point we may revert to William, whom in a previous page we have brought to the neck, at 219 feet altitude, at which he deployed. He was not yet aware of Harold's weakness in bowmen; but as the central portion of the English line was rather more than 200 yards from the neck, he was able to keep out of arrow range until the movement was completed. The ground lent itself admirably to its accomplishment, for he had not to cross either of the ravines to east or west, but was able to deploy along a contour line, which was about 50 feet below the line to be attacked. The Norman army was in three divisions; and in the arrangement of the line were placed in geographical order. On the right the men of eastern France, Picardy, and Flanders, many of whom were mercenaries, extended from the neck towards the point at which the slopes began to bend round the English position; the Normans, under the Duke's personal leading, covered the centre of the position, their right resting on the neck; and the men from Brittany, Maine, Anjou, and western France were on the left, extended to the top of the steep slope which fell towards the rivulets in that direction. It seems probable that the men of each contingent furnished by a baron or knight were massed separately in

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some wedge-like formation under their own chief; the infantry being in front in the intervals between the horsemen, and the bowmen extended in advance of the former. We have no precise evidence to show the exact arrangement, and it would be incorrect to endeavour to indicate it by the usual rectangles; a simple line has therefore been adopted to mark on the plan the general extension of the Norman army at 9 a.m., the bowmen being shown conventionally. The word "Bowmen" is used in preference to "Archers," because the bow used was a very small one, with a considerably shorter range than the famous English long-bow of Cressy, which was not introduced until two centuries later.

But although the precise formation of the units of the Norman army is uncertain, a speculation may be made on the numbers it was possible to deploy along a line generally following the 200-feet contour between the limits east and west at which the slopes turn sharply northwards. The length of the alignment was about seven-eighths of a mile; and as we suppose the infantry were placed between the horsemen, the latter cannot have been at smaller intervals than two-and-a-half yards. Allowing some break between the divisions, and supposing there were four mounted ranks, a calculation gives us 2,464 as the cavalry strength, exclusive of reserves. If we take the infantry in the proportion of two men for each horseman, and the bowmen at one for two horsemen, we can obtain the following result;—

Cavalry (in four ranks)	2,464
Infantry	4,928
Bowmen...	1,232
Total	8,624

As the Normans were stronger than the two other divisions combined, and the Bretons rather stronger than the French, we may suppose the force to have been divided, approximately, as follows:—

	Bretons.	*Normans.*	*French.*	
Cavalry	650	1,300	514	
Infantry	1,300	2,600	1,028	
Bowmen	325	650	257	
Totals ...	2,275	4,550	1,799	men.
Approx. frontage ...	405	815	320	yards.

The results obtained by these methods of reasoning are wholly different from the popularly accepted numbers on the opposing sides. Against 20,000 to 25,000 on the English side, we have, on reasonable grounds, been able to account for 10,900 only; and on the Norman

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side, against 60,000, only 8,624. In the previous calculation we came to the conclusion that 11,000 men may have been transported across the channel; and when due allowance is made for reserves, casualties, men left on the communications, and sick, the total 8,624 is as high an estimate as can be made of the numbers likely to have been in line on the battlefield.

The juggling feats of Taillefer, and the dramatic episode (mentioned by Wace) in which he sacrificed his life, may be passed over as without military interest; and we now reach the point at which the actual fighting commenced. Soon after 9 o'clock the preparations were complete, and William ordered a general advance along the front. In the armies of the 11th century, previous to this battle, the majority of the fighting men had usually been cavalry, while the infantry had been a much despised arm. But at Hastings footmen were employed in larger proportions, for two reasons—the difficulty of transporting horses over the sea, and the reputation recently gained by the English infantry. William's tactics were, after preparing the attack with his bowmen, to assault with infantry, not caring how many of the despised arm he sacrificed, and to charge with cavalry when the defence was shaken. The infantry, whose hair was worn short, were in most respects very similarly clad to the English; some had chain shirts and iron caps, but the greater number wore leather jerkins and caps, while many had the simple blouse of the French peasantry; their legs were bound with thongs, and they were shod with sandals; their arms were short axes, spears, daggers, and broadswords. In discipline and courage they were not inferior to the English bodyguard, and in all respects were better than the English light-armed levies. But their opponents had the great advantage of being posted on the top of a steep slope, and it was the first experience of the Normans against the famous housekarls, with their shield-wall and two-handed axes. If there were any engineering obstacles, these also had to be surmounted; but even if there were not, the task before William's army was a most difficult one. We cannot wonder, then, that the first assaults failed at every point. A desperate resistance was encountered, and the storm of missiles of every description showered on the assailants is described as quite unprecedented.

On the left, as may be seen from the plan, the Bretons advanced up a comparatively easy slope, and doubtless reached the English line more quickly than the Normans in the centre; being unsupported, at first, on their right, the full opposition was concentrated against their attack; they were thrown into confusion, and fell back in disorder. It had been strongly impressed on the English that the only hope of gaining the day depended on their remaining steady on their own ground of vantage; but the ill-disciplined levies on the west of the ridge, seeing the Bretons retiring, could not restrain their excitement, and rushed down the hill in pursuit, crying

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"Victory." Their triumph was short-lived, for William's highly-trained cavalry on the slope in the centre lost not a moment in attacking the pursuers in flank; and it is reported that very few of the brave Englishmen were left alive to return to their lines, though some of them may have escaped through the wood on the west. In the repulse and retreat of the Bretons occurred the greatest loss sustained by the Norman army during the whole day. The baggage guard even was in danger, and indeed for a short while there seems to have been an absolute crisis. William of Poitiers states that the issue of the battle was in doubt and hung in the balance until 3 o'clock. The valiant conduct of Bishop Odo in rallying the flying Bretons is specially noticed by William of Poitiers; he is shown on the Tapestry clad in coat-of-mail, striking into the *mêlée* with a mace (being an ecclesiastic he was not allowed to use a sword). Duke William himself also assisted in arresting the flight; a rumour had spread that he had fallen, and he is reported as having lifted his visor to show his face in order to re-assure the army that he was alive.

The Norman army fell back along the whole line to re-form. Many times during the day the attack was vigorously renewed, and as often failed. The stand made by the English has been compared to that at Waterloo, but there was an essential difference between the cases, arising from the unsteadiness of the light-armed men; had they stood doggedly on their ground like Wellington's squares, the issue of the battle might have been quite other than it was. William was personally foremost in the fray, but still his cavalry could not penetrate the English line.

Towards the afternoon, remembering how the light-armed men had left the line in pursuit of the Bretons in the morning, he conceived the idea of feigning defeat in order to tempt them to do the same again. But this time his retreat was made in the direction of the Hastings road, where he knew the advantage of higher ground would soon be on his side; and at the critical moment the French on the east fell on the disorderly crowd of pursuers on their flank, and effected immense slaughter. This manœuvre seems to have been repeated more than once, with the result that the English strength was so materially weakened that it became necessary to concentrate for the defence of the Standard, thus leaving their right insufficiently guarded. The Normans on the west, who were only waiting for this to happen before renewing their attack, succeeded, about 3 o'clock in the afternoon, in getting to the top of the hill behind the line on the English right. The cavalry were now able to move rapidly along the ridge, on fairly level ground, in the direction of the Standard, round which the housekarls maintained the shield-wall unbroken, the low-aimed arrows of the Norman bowmen being caught in the shields. This being observed, the bowmen were ordered to give greater elevation in order that their shafts should fall at a high angle on the

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English rear ranks. The arrows "flew thicker than rain," and before long one pierced the eye of Harold. From this moment the issue of the battle was no longer in doubt. William, however, continued to engage the housekarls hand to hand in a prolonged struggle; his men suffered much from the terrible two-handed axes, but gradually gained a footing on the high ground. King Harold and his two brothers fell fighting to the last in defence of the Standard; and it is stated that the crowd round it was so dense that the wounded were trampled under the horses and the living marched over heaps of the dead.

William, from the top of the hill, noticed that the English left was gradually becoming weaker, and sent an urgent order to the French division, which was engaged down the outer slope in completing the defeat of the last sortie, to detach a body to assist the main attack at the east end of the ridge. From the *Carmen de Bello Hastingensi*, we learn that Eustace of Boulogne, with two Norman knights and a body of stragglers hastily collected, came up in obedience to the order, and got inside the line on the extreme English left. I cannot, myself, consider this as the first time the English line had been penetrated, as I believe Mr. Baring does, but I think Eustace's attack very possibly hastened the English flight, the day having been virtually lost long before.

It was dusk, and nearly 6 o'clock; all the leaders had fallen, and the housekarls lay dead to the very last man round the captured Standard; the few survivors, mainly the light-armed militiamen, broke at last, and fled in complete confusion in all directions.

I have frequently discussed the incidents of the battle with Mr. Baring, and in company with him and Sir Augustus Webster, the owner of Battle Abbey, have examined the ground. In nearly every particular I am in full agreement with him, but in one respect we differ in opinion. He attributes a larger share in the battle to the French than I do, and does not accept my view that the first penetration of Harold's line was by the Normans at the west end of the ridge. According to my reading of the chronicles, the repeated mention of the Normans and Bretons in the description of the late stages of the battle shows that the principal scene of the fighting at that time was the Norman left-centre and left; while, on the other hand, little is said until the final phase of the action of the French division, beyond the mention of the assistance given by it in repulsing the sorties on the Hastings road. It seems to me that the penetration of the line by the French at the east end was, as I have stated in other words, nothing more than a final movement in support of the men already fighting on the hill; and that the victory would have been equally assured if it had not taken place.

The horses of William's army had been saddled twelve hours or more, and were thoroughly tired out; and I imagine the final pursuit must have been made by the French, whose mounts were the only

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comparatively fresh animals. Most of the fugitives ran towards the north-west, in which direction for half a mile the ground was fairly level and open; the pursuing cavalry, in their fury, appear to have lost all discipline, cutting down the helpless English mercilessly. It was by this time almost dark, and the reckless riders failed to notice that the ground was intersected by the head of a ravine about half a mile from the position on which the Standard had stood. Its steep bank was concealed among bushes, and became a death trap into which a large number of horses and their riders fell. The retreating English turned a moment in their flight, and took a last revenge by killing every fallen Frenchman; their further pursuit by the Norman army was abandoned.

The site of this disaster, which the chroniclers refer to as "the Malfosse," is erroneously marked on Freeman's map on the east side and at the left-rear of the battle ridge. Sir James Ramsay perceived it was on the west side, but marked it much too near the Standard. The site now indicated was suggested by Sir Augustus Webster, and Mr. Baring has proved that he is correct. It would take too much space to give the documentary evidence quoted by him in support of his arguments, which I accept as most convincing.

The present state of the battle ground is difficult to compare with what it must have been in 1066. There can be no reasonable doubt that the ruins of the Abbey Church founded by William the Conqueror mark the exact position on which stood the English Standard at the end of the battle and where Harold was killed; and on this spot a monument to Harold has recently been erected by a French society. The ground which was then quite open is now covered with trees and gardens, and the even slopes up which the Normans advanced have been completely altered in character by walls, retaining terraces upon which the fine abbey buildings stand. To the east of the position of Harold, and on the line of the Norman approach from Telham hill, the site is covered by the houses of the village and the railway. Although there are many trees on the south-west angle of the battle site, it is the only part of the ground which to some extent is the same in contour as it was in 1066. On the plan an endeavour is made to show the ground as it was at the date of the battle.

The romance of the finding of Harold's body and its supposititious interment on the seashore is too well known a story to be repeated. The English army had ceased to exist. William's loss cannot be stated, but was so heavy that he was too crippled to advance at once. Falling back to Hastings, he obtained reinforcements there before marching along the coast to Romney and Dover; and he was not able to commence his march from Canterbury to London until after December 1st. His exact movements need not be traced further.

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MEMOIR.

Lieut. St. J. G. Spackman, R.E.

St. John Gaisford Spackman, who was killed on October 8th last in an accident while playing polo for the Corps at Campamento near Gibraltar, was born at Christchurch, New Zealand, on November 21st, 1881.

He was the eldest son of the late W. H. Spackman, Barrister-at-Law of the Inner Temple, and of Mrs. Spackman; and was educated at Cheltenham College, where he soon gave evidence of that keenness in everything he did which distinguished him all his life and especially during his service at Gibraltar. He gained an entrance scholarship to Cheltenham in 1896, and after two years there passed into Woolwich, having earned the golden opinions of all with whom he was brought in contact. He was a very good French scholar, having spent several years in France, and while at school gave proof of his ability by gaining the silver medal given by the Société Nationale des Professeurs de Francais en Angleterre. He followed this up while at the Shop by winning another prize from the same society. In all his games at school he showed that keenness which was the foundation of his surprising record at Gibraltar, but he was somewhat handicapped by want of size (he always rode about 9 stone) and a damaged knee.

Spackman received his commission in the Corps in May, 1900, and joining at Chatham shortly afterwards went through the usual courses with his batch. At the end of his time there he was ordered to Gibraltar where he arrived in September, 1901. The conditions of the life on the Rock entirely suited his bright disposition and sporting nature; and those of us who were there when he joined must remember the keen way in which he took up both work and sport. He soon proved himself to be the best of comrades, and his unfailing good-temper and his readiness to help others won him many firm friends. A still brighter side of his character was displayed by the way in which he bore the heavy responsibility thrown on him by the early death of his father. His work was always thoroughly well and conscientiously done, while his success in the various forms of sport was little short of phenomenal. In the annual Hunt Point-to-Point Race alone he set up a record which will probably stand for many years to come, being placed in the first ten on all five occasions when

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he rode. He was 9th (with a fall) in 1902, 8th in 1903, 2nd in 1904, 10th (with a fall) in 1905, and 2nd in 1906. On the last occasion he won the Individual Prize, and also the cup presented by Lord Charles Beresford and the Officers of the Channel Fleet. He also met with great success on the only occasion that he joined a pig-sticking camp in Morocco. He took up racing very keenly, both training and riding his own ponies; and among his many successes were the Subalterns' Cup, a two-mile steeplechase, in 1904, and the Hunters' Flat Race in 1904 and 1906. His victory in the Hunters' Flat Race of 1904 will long be remembered by those fortunate enough to see it, and his win in the steeplechase for the Berkely-Milne Cup last May was also one of his happiest efforts. He was among the best polo-players in the Gibraltar garrison, in fact in his place as No. 2 he had few equals.

In September, 1906, he was ordered home, and was hoping to close his connection with Gibraltar sport by helping the Corps to win the Annual Polo Tournament, one of his most cherished ambitions. Right well did he play his part, and it was in the final game, when success seemed almost certain, that the accident occurred. He is gone; and while the Corps loses a good officer, his friends are left to deplore the loss of one of the best of sportsmen and a true and valued comrade. He lies buried at the North Front, Gibraltar, the scene of many of his sporting successes, in the shadow of that Rock on which those five happy years of his short life were spent.

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TRANSCRIPT.

THE STRATEGIC TRIANGLE AND THE ENGLISH ALLIANCE.*

To exist without sea power is a material impossibility for the United Kingdom. Its growing population of 43 millions, with a restricted agriculture and highly developed industries, necessitates an enormous maritime activity and very large imports of food and raw material.

This statement is universally acknowledged, and no lengthy statistics are required to prove it; but a few figures may well be given in order to accentuate the fact. According to the *Statesman's Year Book*, Great Britain and Ireland in 1905 produced 45½ million cwts. of wheat and imported 116½ million cwts. (in round numbers); that is to say, the country only produced 28 % of the people's needs. Similar figures might be quoted with respect to other cereals, flour, meat, sugar, etc. The same statistical volume registers for 1903 some 133 million lbs. of home-grown wool against 639 million lbs. imported; and importations of 1¾ million lbs. of cotton and 30 % of the total of iron ore.

Without any further examples it may be accepted that the United Kingdom absolutely cannot exist within its own frontiers, and that a successful blockade would cause an insuperable crisis in the labour market and trades, serious economical troubles, and before long, however great the preventative storage in peace time, a famine.

Moreover, the United Kingdom forms the heart of an extensive Empire, of which the united existence cannot even be imagined without assured liberty over the intervening seas that link up the numerous dependencies scattered all over the globe, some of them (such as India and Canada) incapable in themselves of providing for the defence of their land frontiers.

In proof of the importance which is attached to this aspect we may cite the diligent study in England of the question of "Commerce Protection in War," which has been a subject of discussion at the Royal United Service Institution and a problem in recent Naval Manœuvres.

There is no doubt that the work of the 20,000 mercantile vessels registered in the United Kingdom constitutes for the life of this country a circulation of blood, the suspension of which would seriously effect the whole normality of the national organization.

* A *précis*, by permission of the publishers of the *Revista de Artilharia*, of an article contributed to the August, 1905, number of that Journal by Capt. Henrique de Paiva Conceiro, Portugese Artillery, who kindly provided an English translation.

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The following five main lines of sea traffic, all marked at intervals by permanent stations, ramify from the centre, England, to the extremes of the great Empire :—

1. *North-Westwards.*

North Atlantic Ocean — Trans-Canadian Railway — Pacific Ocean. (Stations :—Halifax ; Esquimalt).

2. *Westwards.*

Mid-Atlantic Ocean. (Stations :—Bermuda ; Jamaica ; Barbadoes).

3. *South-Westwards.*

South Atlantic Ocean—Cape Horn. (Station :—Falkland Is.).

4. *Eastwards.*

Atlantic Ocean—Mediterranean Sea—Indian Ocean—China Seas. (Stations:—Gibraltar; Malta; Alexandria; Aden; Colombo; Singapore; Hongkong; Wei-hai-wei).

5. *South-Eastwards.*

South Atlantic Ocean — Cape of Good Hope. (Stations :—Sierra Leone ; Cape Coast Castle ; Ascension ; St. Helena ; Capetown).

From Capetown this route may be prolonged (*a*) to India (Station :—Mauritius) or (*b*) to Australasia (Stations:—Melbourne, Sydney, Brisbane, Hobart, Auckland).

In connection with these oceanic roads we must consider the telegraph cables which are their complement. Through certain powerful private companies England to a great extent dominates the whole mesh of the submarine cables of the world. According to the contracts between the Government and these companies, official messages always take precedence, no aliens are employed at the stations, and in war the Government can assume entire control.

From the very extensive and ramified network of cables we need select for our purpose the four following, which we may suppose to be the main direct military strategical lines :—

1. *Westwards.*

Ireland (Valentia) — Halifax — Vancouver — Fanning I. — Fiji Is.— Norfolk I.—Brisbane.

2. *South-Westwards.*

Ireland—Halifax—Bermuda—Jamaica—Antilles—Georgetown.

3. *Eastwards.*

England (Penzance)—Gibraltar—Malta—Alexandria—Suez—Perim I. —Aden — Bombay — Madras — Penang — Singapore — Labuan — Hongkong.

4. *South-Eastwards.*

England—Madeira—St. Vincent (Cape Verde Is.)—Ascension I.—St. Helena I. ; Capetown.

From Capetown lines run :—(*a*) Up the West coast of Africa by Mossamedes—Benguela—St. Paul de Loanda—St. Thomas I.—Bonny ;

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(*b*) up the East coast of Africa by Durban—Mozambique or by Durban—Mauritius—Seychelles Is.—Zanzibar; and (*c*) to Australia by Mauritius—Diego Rodrigues I.—Keeling I.—Perth.

This electric web, by which the dispersed sentry posts of the British Empire are linked to the brain centre, and unity and direction are simultaneously afforded to her far-spread forces, assumes an importance which could be proved by citing historical instances of its diplomatic and military use but is self-evident.

Wireless telegraphy, notwithstanding its valuable services in sea command, does not at present supersede submarine cables for large distances. It also has its disadvantages: witness the instructions to the cruiser *Minerva*, in the English Naval Manœuvres of 1903, to scout 40 miles ahead with the object of intercepting the enemy's messages.

From the above we see evident, in its capital features, the strategical system of navigation and telegraphy as veins of activity and force invigorating the British Empire and ensuring for it an unsurpassed supremacy and unrivalled prosperity.

As, however, this lever of English power is open to attack, we require to examine the probabilities of such an occurrence.

Peoples exist who, from a hard struggle for life and under the impulse of ever-increasing population, production, and trade, are compelled to seek for expansion, for wider territories and more markets, so as to reduce the tension at home. Such expansion follows the line of least resistance, either to neighbouring countries less highly developed or less thickly populated, or to countries over sea. In this phenomenon of expansion we may notice a physical aspect, corresponding to the spontaneous internal pressure of a body that dilates; and also a moral or politic condition which, known as 'Imperialism,' represents the tendency to dominate, one day pacific, another warlike, sometimes proclaiming the excuse of civilizing assimilation, sometimes the fatalistic theory of natural selection.

The manner in which Imperialism displays itself and grows amongst the various nations of Europe, Asia, and America is of greater significance to us in prophecying future collisions than are some of the ostensible diplomatic combinations. The antagonism of diverse Imperialisms may, indeed, be compared to a mathematical equation involving the essential interests of peoples, the predominance of races, and the importunings of a struggle for life. Japan, the United States, England, and Germany are at this moment the most typical.

Japan, pressing Russia back from Korea and, to a certain degree, from China and the Pacific, has marked out for herself a sphere close to her own borders.

The United States, whilst maintaining the Monroe Doctrine, have established naval stations in the Caribbean Sea, in Honolulu, and at Manila, and are about to construct the Panama Canal as a waterway under their control.

For England the Japanese alliance has secured some safety in the East, and also the possibility of a reinforcement to her naval strength in European waters. This alliance seems to indicate that these two

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Imperialisms have fairly shared separate spheres of action. As regards the United States, the Hay-Pauncefote convention and the solution of the Alaska frontier question, with other symptoms, appear to show a real disposition, at least on the part of England, to tighten the bonds of friendship between the sister races.

Germany, active, prolific, with flourishing industries, supplies the bulk of emigrants to America; she rules over some islands in Oceania, guards a door in China, promotes economic expansion in Asia Minor, and possesses some colonies in Africa, of which unfortunately the one most suitable for settlement by whites is rather unproductive. A great Empire may, perhaps, consider this a poor estate, deficient in Oceanic stations and in zones for the reproduction of the race under the national flag. Germany, therefore, appears to be most likely to cause the gathering cloud. But, in view of the fickle and kaleidoscopic nature of international relations, it is impossible to say that the storm may not arise in another quarter. A previous volume of the *Statesman's Year Book* alludes "without hostility to the United States" to the possibility of a conflict between England and the great North American Republic, which will soon become the second naval power in the world.

Thus the antagonists to whom we must pay attention are:—Firstly, Germany (or the Triple Alliance); secondly, the United States (or an American group). The Dual Alliance, France and Russia, has for the time lost part of its influence.

The gradual increase of her fleets, in order to obtain a permanent superiority on her own element over the growing navies of her possible adversaries, has been a principle of the Governments of England. Granted the existence of such a superiority, experts have engaged in controversy as to its best utilization in practice and as to the method of naval warfare most profitable to England. There is, however, agreement in the main principle—To oblige the enemy to fight, and to maintain vigilance over his ports. This is a logical principle for a power pre-eminently strong, both absolutely and relatively.

But the principle needs qualifications for several reasons. Similar logic would inspire inverse action on the part of the enemy, namely, to avoid a battle at sea and to operate against the undefended coasts or, especially, the vital merchant shipping: the scale of such action by the enemy would depend on the efficiency of the protective service, the distance between the zones to be guarded, and the limit of torpedo boats. The efforts of certain powers to increase their navies may eventually weaken the relative superiority that has hitherto been the possession of England. The English authorities, with clear foresight and great knowledge, have confirmed the existence of a reverse side to the medal by studying the problem and preparing for the direct defence of maritime traffic.

Thus a direct defence forms an English object in war. As to the method of protecting commerce, three alternatives are discussed, namely, escorted convoys, the policing of maritime routes, and direct pursuit of hostile *Alabamas*. The first system implies the formation of columns; it introduces normality into mercantile circulation; and its efficiency (as does that of the second method) depends on a large number of naval

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units. The third means, though requiring less in quantity of warships, presupposes oceanic search and contact with the enemy, an operation difficult of execution.

'Scouting' is the term employed in England for the complicated art of exploring large sea areas with several ships manœuvring dispersed under a connected scheme, which gives each of them a direction and a speed so calculated as to obtain from the whole an extensive drag net with no openings for the escape of the enemy and no disconnections that can hinder an eventual concentration. These searches and, generally, all attack and defence on oceanic high roads mean movement, and that means fuel consumption, so that the whole set of combinations must be worked out according to the position of coaling stations; hence the English phrase 'coal strategy,' and the persistence of its authors in establishing all over the world numerous depôts of Welsh coal, the real nerve of the evolutions of their fleets.

Various means have been employed to lessen the degree of necessity of this storage of coal at ports; for example, colliers, liquid fuel, the increase of bunker capacity. Shipping coal at sea depends upon the condition of sea and weather, and, moreover, colliers in their turn also need coal for themselves; this method must result in sailings to and fro, with waste of fuel and danger of capture. The use of oil fuel does not dispense with the necessity of periodic replenishment, and, according to Jane's *Fighting Ships*, 1905–06, is still in an experimental stage. Finally the art of ship-building meets with difficulties in increasing coal-carrying capacity, on account of the weight of coal, the space required, and questions of stability.

In any case the radius of action of any ship, that is the greatest distance she can cover on her own load of coal, is a variable quantity, depending on the speed and on the conditions of the engines, the sea, and the weather. A French commerce-destroyer, for instance, reached only two-thirds of her expected 7,500 miles. Some writers allude to cruisers with between 10,000 and 15,000 miles limit; but, having regard to published statistics of fuel consumption and bunker capacity in the best cruisers of different navies, we cannot verify distances exceeding 10,000 miles, and this is the lesson of the British manœuvres, if we interpret rightly some pages of the 1900 and 1904 *Naval Annual*. Indeed, experiments tend to show that nominal radii of action must be given large co-efficients of correction in practice; and, as we require some definite figures on which to base our further arguments, we may assume that 8,000 to 10,000 miles (and this is applicable only to the best cruiser groups in each navy) will represent a maximum that can be accepted.

So much for fleets. Submarine cables form a most important instrument in the direction and success of naval operations; they are naturally indicated as objectives for attack, as evidenced in the Spanish-American War. The cut may be attempted either near the actual point of an attack where the cable would be easier to find, or on the high seas, when the greater difficulty of the task would be balanced by the lesser danger of interference. Proper tools for cutting purposes are in existence, and it is said that in depths of less than 500 mètres an attempt might hope for success.

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Let us now examine the five sea-roads which, as above mentioned, run from the United Kingdom to its political and commercial dependencies.

The Trans-Canadian Railway, included in the first route, introduces some elements of inconvenience—a double transhipment, and insecurity on account of its proximity to the United States frontier.

The fourth route, through the Mediterranean, though strongly protected, has the drawback that it passes alien military ports which might be hostile, through narrow waters, and through the Suez Canal which might easily be obstructed.

Thus, we have only the remaining three which are both safe and spacious; and these we may call "the Atlantic Routes," for they run either wholly or mostly over that sea.

The Panama Canal promises to be in the future a factor requiring close consideration. It will be dominated by the United States. True we cannot presuppose unconditional free passage for belligerents; but we must allow for the freedom of movement between the west and east coasts guaranteed to the American fleets and only to them.

Thus the *Atlantic*, in all its length, from north to south, constitutes *the key of British communications*.

If we consult the *Statesman's Year Book*, we find the origin of the greater, and also the most necessary, portion of the imports of the United Kingdom; and we can conclude that the command of the Atlantic and of its prolongation in the Indian Ocean guarantees the supply of victuals and of work to this Kingdom, because this is the route of transit from Canada, the United States, Argentina, South Africa, India, Australia, and New Zealand, which countries are the principal providers of cereals, meat, cotton, and wool. The same route affords mutual aid between the Mother Country and its remote Imperial Dependencies.

Evidently the command of the Atlantic is a primary objective for England; and we may now briefly define the problem of this command from the British standpoint.

At any given moment the distribution of the British naval forces is a reflection of the state of world politics and also of the comparative strengths of the world's navies. At the present time the reinforcement of the Channel Fleet denotes preoccupation on the German side; and this fleet, though liable to diminution on account of changes in the political horizon, cannot lose the importance of its *rôle* as a permanent protection in territorial waters. *Mutatis mutandis* analogous conclusions may be drawn in regard to the Mediterranean fleet. Thus two large groups of the best battleships and the proportionate cruisers must always, according to reasonable conjecture, be absorbed in questions of defence that admit of no postponement.

Consequently, even omitting consideration of other naval exigencies of the vast British Empire, however numerous may be her fighting units, the strength purposed to guard the Atlantic must be calculated with relative economy as regards both quantity and quality. And here we may note that whether the attack comes from the North Sea round Scotland, or from the opposite American coast, probably nothing can prevent the attackers choosing their hunting grounds on the lines of the commercial routes.

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Thus, on the one hand the strength to guard these routes is limited, whilst on the other the area to watch is almost unbounded; so the solution of the problem must be sought in adequate strategy.

The accompanying map at once suggests the idea that, with Madeira (Lisbon or Lagos) and St. Vincent eliminated, the chain of assistance or support between the extremes at Plymouth and Capetown exhibits remarkable deficiencies, for the first refuge from Plymouth is Free Town, some 3,000 miles distant. But when we insert Madeira and St. Vincent we get, with Ascension and St. Helena, a continuous chain linking England with South Africa. The points mentioned form a line of sentries at suitable intervals, roughly:—Plymouth—Madeira, 12,000 miles; Madeira—St. Vincent, 1,000; St. Vincent—Ascension, 1,400; Ascension—St. Helena, 700; and St. Helena—Capetown, 1,700. These sentry posts, moreover, are well clear of continental coasts, Madeira being some 500 miles from the European littoral, St. Vincent 500 from the hump of north-west Africa, and the two other islands 1,000 miles or so from the retired littoral of southern Africa. The places mentioned thus mark natural stations on the Atlantic road from England to the Cape.

Similarly the map points out Plymouth—Madeira—St. Vincent—Pernambuco as the natural stations connecting England with South America; and in this case the omission of Madeira and St. Vincent would mean an unbroken run of more than 3,500 miles.

Again the map clearly points to the Azores as the first link in the chain connecting England either with North America, or with Bermuda, or with Barbadoes. The Azores indeed stand nearly at the middle of the long journey of 3,000 miles to the two last-named goals. Moreover, in the whole of the North Atlantic we find no points that could be substituted for the Azores on the route to North America; and on the roads to South America and Africa we have only the Canary Islands, of which the position is unfavourable, Teneriffe being some 2,100 miles from Ascension and 2,300 from Pernambuco.

Still referring to the map, let us remember that in discussing methods of protection of sea-borne commerce in war, whether by convoys, by policing of routes, or by direct attack of commerce destroyers, we concluded that 8,000 to 10,000 miles was the practical limit of the sphere of ship-power, and this, moreover, only to be expected from a restricted number of ships; and that later on we concluded that Great Britain could not afford to dispose of her best cruisers for continuous duties in the Atlantic. Since the services of policing and of direct attack presuppose speeds greater than the most economical, and consequently a reduction in the radius of power, it will, for the purpose of argument, be safest to adopt as the sphere limit a distance of 3,800 miles, which is equivalent to 12 days' navigation at 320 miles per day and a coal consumption of 1,800 tons.

With these data we can now consider how the number of cruisers that should be employed and their most economical use is effected by the question whether the coast and the oceanic islands of Portugal can or cannot be counted upon in the strategical problem of the command of the Atlantic. Parenthetically it may be remarked that the British naval

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authorities have paid much attention to the matters of vigilance, search, and pursuits in extensive ocean areas, and various methods have been tried in successive naval manœuvres; but we have no means of determining what particular system would be adopted. However, whatever the system may be, the conclusions arrived at on the basis of distances and radii of action may hold good.

Taking first the route Plymouth—Bermuda, if the Azores be ignored, the route must be secured either by a direct service from one base to the other, or by entrusting half the total length to each of two cruiser fleets, each acting from one of the bases. In either case we must calculate 3,000 miles (9 days' navigation) for the complete voyage, which leaves only 800 miles (3 days) for search and chase. But, if the Azores, in their favourable position midway, be available, the dead stretch is reduced by half; and if we have ships operating east and west therefrom, the mileage remaining for offensive service is increased to 2,300 miles (7 days' navigation). The same results are seen on considering the route Plymouth—Barbadoes.

Similarly the route Plymouth—Pernambuco, if Madeira (Lisbon or Lagos) and St. Vincent be eliminated, means a dead stretch without supporting stations. True that Gibraltar lies near the route; but it is really outside the Atlantic, and has the disadvantage of being in a narrow; and to it, rather than to Malta, belongs the *rôle* of base for the Mediterranean fleet. The inclusion of Madeira and St. Vincent divides the route into three almost equal lengths of about 1,000 miles, which, with the 3,800 miles limit of action, leaves 2,800 miles for offensive service.

Like reasoning and deductions can be applied to the Plymouth—Ascension portion of the route to the Cape, to which Madeira and St. Vincent supply a complement of the greatest advantage.

Underlying the maritime roads are the cables, all emerging at strategical points. If we examine the list, given above, of the cables selected as the most characteristic, we find that the three first are connected only with British territory. The fourth, that to the Cape, makes use of Portugese territory in Madeira and St. Vincent; but, except for these points, only emerges at two other places, both British, namely Ascension and St. Helena. The *rôle* of the Portugese Islands is thus still further accentuated.

We have above endeavoured to define the connection, in the general strategical problem of the command of the Atlantic, of the group of three maritime positions—Madeira (Lisbon or Lagos), the Azores, St. Vincent—which we call "The Strategic Triangle."

Figures have been quoted, without pretension to exactitude, which is for various reasons unattainable, to illustrate the broad features of our reasoning and its palpable conclusions. Certain factors of course cannot be accurately defined and are moreover inconstant.

Recapitulating, we have on the north side a nation (England) for which the command of the Atlantic is a primary objective, and on the south side another nation (Portugal) which is wedded to the same ocean by important interests in commerce and colonial communications. A clear

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advantage would accrue to both, if, instead of approaching their respective tasks independently, the two parties were to work in combination, dividing the task in proportion to the importance of their respective objects, interests, and capacities. Statistics of population, commerce, and internal prosperity afford a basis on which to define how such a proportion of responsibility could be established. Portugal might undertake the security of her naval bases, insular or continental, and England the security of the open seas.

The only neutrality respected by belligerents is the neutrality of a power that has force to command respect. We must defend our islands of the Azores and Cape Verde; they are, so to speak, continuations of our home continent; and the latter further form a stepping-stone to our principal colony, Angola, the sole territory to which we can emigrate under our own flag. The best method of securing the safety of these insular possessions would be, not to defend each island separately, but to defend them as a whole through sea command, basing this command on one island in each archipelago, and fully equipping the two selected points as military stations with batteries, torpedoes, ammunition, victuals, coal depôts, and dockyards. The same reasoning is applicable to Lisbon or Lagos.

The methods of defence will differ according to whether we are a solitary wheel or a wheel included in the general mechanism of the dominion of the Atlantic; but even if we have to face the hypothesis of having to act independently, the subject well deserves full attention.

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REVIEWS.

FELDBEFESTIGUNGS VORSCHRIFT, 1906.

A NEW, provisional, edition of the German "Instruction in Field Fortification," sanctioned by the Emperor on 28th July, 1906, has just been published. It supersedes the edition of April, 1893. Like its predecessor it is a small and convenient volume, 6 inches by 4½, but it contains 111 pages as against 84. Its price bound in boards is 60 *pfennig* or sevenpence.

The general arrangement of the contents, which has been only slightly changed, is :—

Introduction.
I. General Principles.
II. Execution of Field Fortifications.
III. Infantry and Engineer work in Fortress Warfare (formerly entitled "Work in Attack").
IV. Technical Details. This is new, and is divided into
(*a*). Hints on Use of Tools.
(*b*). Tracing Parallels, etc., in Fortress Warfare.
(*c*). Revetments.
(*d*). Construction of Fascines, Hurdles, and Anchorages for Revetments.
Of these (*c*) and (*d*) were formerly contained in appendices.
Appendices.—Tools carried and Table of Penetration of rifle bullets, shrapnel bullets, and shell.

The principal increase is in Chapter III., which is treated in a much more thorough manner, with 28 pages as against 7 in the earlier edition.

The Introduction lays down that all arms are to be instructed in the use of entrenching tools at an early stage of their training; and that knowledge of the proper use of field fortification is to be tested on every possible opportunity, particularly when mixed forces are being exercised. It specially warns officers against constructing field works except under war conditions as to the means available, as such exercises are only misleading.

Engineer troops must not only be able to execute works but must be able to superintend working parties of other arms. Their officers must be prepared to advise commanders on the employment of field fortification in accordance with the situation.

In Chapter I. the general principles laid down are much the same as before, but they are more emphatically and definitely stated. *E.g.*:—in the 1893 edition it was said that "In the attack also the entrenching tool can

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find a use in securing and strengthening captured points." The sentence now reads, "In the attack also the entrenching tool will do valuable service in securing captured points and creating new positions whence a further advance can be made; even under fire its employment can be useful. It is the duty of leaders of all ranks to make use of entrenchments independently if the solution of their task is facilitated thereby."

While formerly the premature fortification of a position was accounted harmful, one is now told only that "Fortifications already constructed must not be allowed to influence new decisions if the situation has altered."

A new principle is laid down that the extent of a position will depend on the intention of the leader as well as on the number of troops available.

It is now laid down that "the artillery forms the framework in the occupation of a position"; that is, it must be considered first and the infantry must fill the gaps.

"As a principle one line only will be selected, and strengthened by all possible means." Advanced positions are not recommended, but it is recognised that it may be necessary to arrange for defended pivots behind specially weak parts of a position. The division of a position into sections for the execution of the work is new, as is also its subdivision into independent battalion groups.

Invisibility is very strongly insisted on. "The most effective protection against artillery is attained when the defensive arrangements are not recognisable even through strong glasses." The obstacles used must not betray the position. The use of dummy entrenchments and masks, the shifting of landmarks, the examination of the position from the point of attack, the avoidance of premature occupation of the position and opening of fire, the importance of a good background, and other similar points are repeated and recommended.

It is now laid down that "the time available is the decisive factor as regards the work to be undertaken. Clearing the field of fire and fixing ranges must be done first; cover comes in the second place."

A special paragraph is devoted to the importance of a good look-out. "It must never be interrupted, either before the position is actually occupied or during the engagement. Each body of troops is responsible for the observation of the ground in front of it, not only as regards scouting and security, but also as regards effect of fire. The observers must not be placed so as to give away the position; they must be able to report quickly, and should if possible be protected from fire." Trees, buildings and ladders are recommended as observatories, and it is suggested that observers in the position itself should use mirrors.

Field fortifications "as a principle" (formerly "as a rule") are constructed by the troops who will have to defend them. The Engineers "are not to be employed to do work which can be executed by the other arms, but are to be used for the construction of the more difficult head cover, for communications, and for obstacles and demolitions." "The Engineers may give the infantry guidance (*Anleitung*) if necessary, but the infantry officers are responsible for the work." "Field and foot artillery will execute their own works independently."

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At the beginning of Chapter II., "Execution of Field Works," stands the sentence "The illustrations are to be regarded as suggestions and not as sealed patterns (*feststehende Muster*)."

The typical fire-trench is now a deep narrow one, without any parapet (4·59 feet deep, 1·96 feet wide at bottom, with sides as steep as they will stand); in the earlier edition it was wide and shallow (1·64 feet deep and 4·92 feet wide).

There is a picture of a man lying on his left side digging under fire; the excavation is at his right side and the parapet at his head. This is new, as is also the section on traverses.

The illustrations of overhead cover show very solid constructions; the flimsy patterns of the previous edition are omitted.

Two new paragraphs and five illustrations describe pits for machine guns, which are given little or no parapet.

There is an entirely new section on shelters for supports and communication trenches, in which attention is drawn to the dressing stations, cooking places, and latrines, etc., that may be required.

A new paragraph mentions the necessity of guide posts and freehand sketches to show the ranges. Firing at night is also alluded to, but no arrangements for it are mentioned.

Utilisation of existing cover remains much as before; but hedges are now spoken of as masks and obstacles only, and the diagram showing the defence of the edge of a wood is omitted.

The obstacles given resemble those in our own *Manual of Military Engineering*.

Having dealt with fieldworks for the infantry the book turns to the requirements of field and foot artillery. In cover for field guns room for a wagon or for ammunition baskets is left alongside the gun, and both in epaulments and pits the parapet is carried well round the flanks. It is, however, laid down that "cover for the gunners is the first consideration and only when there is sufficient time is cover for the guns to be added," and that to make the former will take 40 minutes. Invisibility, overhead cover, connecting trenches between guns, cover for wagons, and observing stations for all commanders are the principal new points touched on.

In the largely increased section on cover for the "heavy artillery of the field army" it is stated that "cover for ammunition must be provided as it is liable to detonation if hit by shell; it can at the same time be used to cover the men." Masks are said to be unnecessary as the guns should be concealed; but to render balloon reconnaissance difficult, the batteries should have growing plants, etc., transferred to them, so as to make the surface similar to its surroundings. Cover for the observation posts is regarded as most important.

Chapter III. deals with "Infantry and Engineer Work in Fortress Warfare." In the general paragraphs an extensive use of obstacles, comprehensive shelter from weather, good communications, and a telegraph or telephone system are recommended. The first heading is "The investment position and covering position for the deployment of the artillery," followed by "Infantry positions and communications." The strengthened

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fire trench is declared to be the best profile for the infantry position, which is to be pushed forward "as soon and as far as possible." "Whether it will be the assault position or whether intermediate positions must be made will depend on the resistance of the enemy."

The execution of trenches and approaches by night and their widening by day are dealt with at some length. Loopholes made South African fashion, through corrugated iron packed with gravel, are illustrated. Sapping, absent in the earlier edition, is now described at length; also the use of corrugated iron for shelters.

Chapter IV. is sufficiently described by its contents. The gabion is not mentioned under the heading of revetments.

It will be seen from the above that the German handbook is by no means so complete a work as our *Manual of Military Engineering* of 1905. It is perhaps noteworthy that a review of the latter (a very complimentary one) only appeared in the *Militär Wochenblatt* last month.

'E.'

REPORT OF THE COLONIAL SURVEY COMMITTEE.

This Committee was appointed in August, 1905, in order that the Colonial Office might in future have the advantage of expert advice on Survey matters. It was recognised that such a body was necessary to ensure uniformity of system and economy of work in the various Crown Colonies in Africa.

The Committee consists of three members:—

A representative of the Colonial Office—H. J. Read, Esq.

The Director General of the Ordnance Survey—Colonel R. C. Hellard, C.B., R.E.

The Officer in Charge of the Topographical Section of the General Staff—Major C. F. Close, C.M.G., R.E.

The Committee's first annual report is a parliamentary paper (Colonial Reports: Annual. No. 500. *The Surveys and Explorations of British Africa.* Wyman & Sons. 2s. 7d.), which contains much interesting information respecting the mapping done in our African Colonies. Useful suggestions are made for the future as regards Survey policy.

The Committee has perforce to recognise that, with the happy-go-lucky Administration of Empire which we enjoy, it cannot expect any comprehensive policy, with the necessary funds to carry it out. It can only endeavour to secure that various detached efforts shall be utilised to the best advantage. Thus, in a Colony where the necessities of the administration cause various areas to be surveyed for the granting of concessions, taxation, etc., the work so done can be compiled if a network of accurately fixed points exist to form a check and link for such scattered areas. For such a network a proper triangulation should be provided; but funds for this can seldom be obtained, and often the most that can be done is to fix the accurate positions of widely scattered towns by latitudes and telegraphic longitudes, and to take advantage of any work done by Commissions fixing portions of the boundaries.

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In recent years local administrations have been making progress in surveying their territories, and the following is a brief summary of the information given in this report:—

Sudan (Director of Surveys, Captain H. D. Pearson, R.E.; Assistant, Lieut. A. E. Coningham, R.E.).—Cadastral surveys in the Dongola, Khartoum, Berber, and Gezereh districts, undertaken for administrative purposes of land ownership and taxation, also some topographical work done in the Red Sea province.

East Africa (Director of Surveys, Lieut.-Colonel G. E. Smith, R.E.; R.E. Assistants, Captain G. S. Knox, R.E., and Lieut. E. W. Cox, R.E.).—Here the Civil Administration started a settlement scheme and advertised it before having any maps on which to issue the title deeds of allotments. A large influx of settlers resulted who clamoured in vain for allotments; and it was reported in 1905 that the usual delay waiting for survey to be made was 12 months. Lieut.-Colonel G. E. Smith's report caused the authorities to institute a Survey Department with himself as Director, and 3 Assistant Directors, a trigonometrical party, and a cadastral party. Annual cost £12,599.

British Central Africa.—A Survey department of one European and three Indian Surveyors started in 1895, and some triangulation was done round Blantyre. The work was pushed forward intermittently to survey privately owned lands till 1903, when a concerted scheme for the Colony was commenced; but no funds are yet available for any systematic triangulation.

Uganda.—A survey department is employed on a systematic survey. So far the progress is:—

Primary triangulation ...	...	...	4,660	square miles.
Secondary triangulation ...	...	...	5,060	„ „
Topography, ½-inch scale ...	...	...	3,000	„ „
Cadastral, 1:10,000 ...	...	...	400	„ „

Gold Coast (Director of Surveys, Major F. G. Guggisberg, R.E.; Assistant, Capt. C. B. O. Symons, R.E.).—In 1901 the gold mining boom caused a great demand for concessions, and consequently for maps. A network of rigorous traverses has been carried out, furnishing an excellent framework for topography. A ½-inch map of most of this Colony, in addition to a cadastral map, will be completed by 1908. Much of the cost has been covered by survey fees charged to mining companies.

Sierra Leone.—No survey department. In 1904 Capt. H. D. Pearson, R.E., with the Colonial Survey Section, made a 1-inch map of 250 square miles round Freetown. A compilation from sketches and boundary work has been made.

Northern Nigeria.—No survey department has yet been formed. Maps have to be compiled from sketches and traverses, aided by the work of Boundary Commissions and the interior points fixed in 1905–6 by Capt. R. Ommaney, R.E., and Capt. G. F. Evans, R.E.

Western Nigeria.—About 1,580 miles of theodolite traverse have been done in Lagos, and a certain amount of cadastral work. A survey department is being formed. It now remains to fill in the framework with detail. Considerable success in training native surveyors to work under Europeans has been attained in this Colony.

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Southern Nigeria.—A limited amount of network in triangulation and boundary work has been accomplished, and fifty astronomical positions have been fixed.

South Africa.—The Geodetic triangulation has been completed, and a chain of triangles run through Rhodesia. A framework therefore exists on which to base future surveys.

In 1904, a conference in South Africa formulated a scheme whereby the various Colonies might undertake the topographical survey; but funds have not yet been provided. Farm surveys exist from which provisional maps have been compiled. They do not show the form of ground with any degree of usefulness for military purposes.

The War Office has accordingly arranged as a temporary experiment to provide a military reconnaissance of Cape Colony under the direction of Capt. C. G. W. Hunter, R.E. Five officers seconded from regimental duty, assisted by six other local officers available during the non-training season, are doing good work of a cheap and rapid nature. It is a compromise between topographical survey and sketching. Using the Geodetic triangulation as a network, graphic triangulation and sketching are done with the plane table in systematic sheets, and a rate of progress attained of about 20,000 square miles per annum.

The Orange River Colony, in conjunction with the War Office, has pursued a very enlightened policy, providing half the cost of a proper topographical survey on the ½-inch scale. This is being conducted by Captain L. C. Jackson, R.E., and the Colonial Survey Section at the average rate of 21·84 square miles per diem, and will be completed in 1911. Total estimated cost for 47,000 square miles, £18,500.

The very able Report under review contains maps showing the survey progress achieved in the various South African Colonies, and also one showing their boundaries already delimited and those still to be done. It not only collates in a useful form valuable informations as to the surveys of Africa, but incidentally shows the urgent necessity for early reliable surveys of new countries if a progressive policy of economic development is to be pursued.

E. P. BROOKER.

REINFORCED CONCRETE.

By CHARLES F. MARSH, M. INST. C.E., ASSOC. M. INST. M.E., and WILLIAM DUNN, F.R.I.B.A. Third Edition, revised and enlarged.—(Archibald Constable & Co., Haymarket. 31s. 6d.).

It will be remembered that a notice of the first edition of this work appeared in these columns about two years ago, and the interest taken in Reinforced Concrete is indicated by the fact that two editions have been already exhausted.

In the third, now under notice, Mr. Marsh has as a collaborator Mr. William Dunn, who rendered most valuable assistance when the book

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was first written, and who is so well known as taking such a practical interest in the development of reinforced concrete in this country.

Since the publication of the work in 1904, the use of this excellent combination of concrete and steel has increased by leaps and bounds and careful investigation has been carried out in many quarters.

In consequence, some 50 pages have been added to the chapter on Experimental Research, which has been brought thoroughly up to date and includes the latest experiments of M. Considère in France, Professor Talbot and others in America and Mr. Dunn in this country. The result of these investigations has been to modify somewhat the data on which previous formulæ have been based, and to give us a clearer understanding of the actual effects in the material under stress.

The chapter on Calculations has been much improved and simplified, and a good deal of unnecessary detail has been omitted, while formulæ for the investigation of bins, silos, tall chimneys, telegraph poles, etc., have been added. The Straight Line Stress Strain diagram has been adopted as the most suitable up to working stresses and this makes for simplicity; and larger diagrams for the investigation of arches have been introduced in this section with good results.

Some new systems of design are noticed, with new types of reinforcing metal.

Under Practical Construction we are introduced to new developments in the use of reinforced concretes (*e.g.* dams for reservoirs, etc.); and under Structures we are brought face to face with the wonderful variety of purposes to which it is applied, ranging from bridges to bins, from sewers to silos, from churches to coffins, from reservoirs to railway sleepers, from warehouses to weirs, from palatial hotels to piers, from sea walls to swimming baths.

Some Appendices on Tests on Pipes, Professor Talbot's most recent experiments, the Prussian Government Regulations, etc., complete a volume which has maintained its title to be considered the standard work on the subject.

The book is brought out in the best style, the printing is good, the paper is good, the illustrations numerous and excellent, and a comprehensive index facilitates reference.

J. WINN.

MODERN PRACTICAL CARPENTRY.

By GEORGE ELLIS.—(12s. 6d. Batsford. London).

Under the above title the author has produced a work which will be found of the utmost use to all engaged in building works, both permanent and temporary.

As a book of reference for all matters included in the carpenter's art, the present volume possesses quite a unique value. Not only is it comprehensive, but the information is supplied at first hand by a practical

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carpenter, who has worked at all branches of the trade, and it therefore abounds in practical details, which only an expert, who has handled the tools himself, could provide.

The work is thoroughly up to date and gives most excellent descriptions of such things as derrick tower gantries (now so extensively used in all buildings of importance), the staging in the Thames at Charing Cross for the construction of the "Bakerloo," the Vauxhall temporary bridge, etc., with working drawings showing details of construction.

The scope of the book may be judged from the fact that it deals with roofs from Westminster Hall to a lean-to shed, with buildings from the dome of St. Paul's to piled foundations, from the scaffolding of a spire to the timbering of a tunnel, from the centring of a bridge above to the cofferdam of the pier beneath, from the simplest floor to the most elaborate half-timbered frontage; in fact wherever timber is used here we are told how it should be used.

Some 1,100 illustrations are employed to show in detail every joint, and over 30 double page and photographic plates add to the general excellence of the whole.

The type and paper are of the best; and though the size and weight of the book would prohibit its use as a pocket book, it certainly should be found in every library which professes to contain books of technical interest.

The author is to be congratulated on the success that he has achieved, and the publisher on the way the work has been brought out.

J. WINN.

THE ANATOMY OF BRIDGEWORK.

By W. H. THORPE, ASSOC. M. INST. C.E.—(E. & F. N. Spon, Haymarket, London. 6s. net).

This little book, which is a reprint of articles that appeared in *Engineering*, is well named. The author has collected a most varied store of information on what we may call the complaints and diseases of all sorts of bridges—timber, steel, and stone.

Some of these bridges suffer from their birth, while others become decrepid from age and the ordinary—and extraordinary—vicissitudes of a stressful life.

The book is nothing if not practical. It abounds in hints as to the diagnosis of the maladies of the long-suffering patients, and suggests suitable remedies.

Every engineer who has to do with the design, erection, or maintenance of bridges would do well to master its contents, and those that do so will be saved from much trouble.

The information is obtained at first hand, which enhances its value. A good index makes the book extremely handy for reference.

J. WINN.

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NOTICES OF MAGAZINES.

NATURE.

October, 1906.

THE PLANET MARS (*p.* 590).—A detailed account of the observations made by Mr. Lowell during the Oppositions of 1894, 1898, 1901, and 1903, at the Flagstaff Observatory in Arizona has been recently published. Flagstaff is situated on the Colorado plateau in latitude 33° N. The steadiness of the air enabled Mr. Lowell to use large apertures with his 24-inch refractor, and coupled with his keen sight and expertness his observations are of the first importance. Even at Flagstaff, Mr. Lowell was not content with the astronomical conditions of "seeing," and he investigated the conditions of a great number of regions in order to choose the most efficient spot for the observation of planetary details. The conditions in Mexico for the winter months appeared to be favourable, and he consequently transported his large telescope with its dome to Tacubaya, near the city of Mexico, in 19° 26′ N. latitude, a distance of about 1,000 miles, an example of American energy and determination to succeed. He has established the certainty of the seasonal change on the planet's surface; the great number of the "canals," 392 being now mapped out; an increase in the number of the oases which lie at the intersection of the canals; an extension of the canals in the dark regions, which proved that the dark areas were not "seas"; changes of shades of the dark areas, showing that they were not bodies of water; and, finally, peculiar markings, termed nicks, were observed where the canals entered the light regions. Since the publication of this work the author is to be congratulated, the results of his labours having been confirmed by a photographic plate recording the canals. The volume is supplied with 13 plates and 76 illustrations in the text, which will give the reader some idea of the number of Martian markings seen at the Flagstaff.

SPEED AND STABILITY IN RAILWAY TRAVELLING (*p.* 637).—This is carefully gone into, and a formula is deduced showing the "critical" speed on a given curve. There are, however, various unknown factors which it would be necessary to take into consideration to enable a true result to be reached; for instance, there is the unequal compression of the springs, causing lateral displacement of the centre of gravity, rush of water in the boiler, and the extent of wear of wheels and rails.

MEDICAL SCIENCE AND ARMY EFFICIENCY (*p.* 612).—The writer of this article sketches the evolution of our army medical service. In the time of James I. no allowance or provision was made for medicines; those details were to be found by the surgeons themselves, for the cost of which a weekly stoppage of 2d. was made from the soldier's pay! It is not until the time of Marlborough that we find any sign of prominence being given to the medical service of the army, but it was fifty years later that the first reforms in military medicine and sanitation were introduced by

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the physician-general to the forces in Flanders. Sir James McGrigor, the principal medical officer in the Peninsula under Wellington, first evolved order out of chaos, and under him the army medical service became an organised body; but in the long peace that followed Waterloo the lessons of old experience had been forgotten, and the army medical service found itself without means to carry out even an antiquated system of professional duty. In 1899 great improvements were made by establishing a corps of 1,000 officers and 4,189 men to meet the needs of the sick and wounded, but there is much yet to be done. During the late war in South Africa enteric and dysentery alone caused 74,000 admissions to hospital and 9,200 deaths. For every man wounded in war 20 sick men are brought into hospital. The unopposed crossing of the Modder river lost us more men from enteric than the battle of Colenso lost us from wounds. Disease prevention is as much a function of the medical corps as disease or wound treatment, and it is to the solution of this problem that the medical corps of the army is now devoting itself, with the sympathetic support of a large number of commanding officers. The army at large, from the highest to the lowest, must be educated to appreciate the need of radical reforms in the direction of preventing disease, and to understand that these cannot be secured "by order" only, but require personal effort on the part of each individual and the recognition by officers of their own direct responsibility for the health of their men.

November, 1906.

THE DYNAMICS OF BOWLING (*p.* 8).—"GREAT BATSMEN," by G. W. Beldam and C. B. Fry.—From the purely cricketing point of view this book must be of great interest, because it proves the wonderful variety of method by which different bowlers effect practically the same result. The movements of the body, arm, wrist, hand, and fingers are all co-ordinated to the one end of imparting to the ball a definite combination of translation and spin. The problem of the dynamics of the "break" is simply that of a rotating sphere impinging obliquely on a rough surface, and is familiar to everyone who has handled a billiard cue. The point of interest to the would-be bowler is how it is effected. This is discussed in the book by Messrs. F. R. Spofforth, B. Bosanquet, and R. O. Schwarz. The introductory chapter by the "Demon Bowler" is capital reading. The questions of swerve and break have much scientific interest. The main fact is that all "swervers" project the ball with the seam as nearly as possible in a vertical plane; in the grip the fingers do not touch the seam, although in some cases the thumb does. The seam is really a roughened zone on which the air may be supposed to exert a greater frictional force than on the other parts of the ball, especially if the ball be new. The volume contains 464 action photographs of some of the most celebrated bowlers of our day.

THE FIRST "MANNED" FLYING MACHINE (*p.* 35).—On October 23rd the first flying machine, "heavier than air," successfully raised itself and its driver, M. Santos Dumont, from the ground several feet, and transported itself by means of its own power a distance of eighty yards. The machine is built on the aëroplane principle and mounted on two wheels.

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It is fitted with an eight-cylinder 60 H.P. motor, weighing about 170 lbs., which drives an aluminium fan making 1,000 to 1,500 revolutions in a minute. With its driver the machine weighs about 750 lbs. The äeroplane is shaped like a large horizontal T. The short arms of the T are slightly inclined upwards, and are each composed of three compartments, like three box-kites tied together side by side. At the base of the T is a large compartment, also like a box-kite, which acts as a powerful rudder at the front end of the äeroplane; the operator stands on a platform midway between, and on a level with, the lower surfaces of the two main inclined arms.

This achievement of M. Santos Dumont will no doubt give a fresh impetus to the problem of flight, and experimenters have now before them a successful äeroplane that can serve as a starting point.

P.S.—On 12th November M. Santos Dumont's airship traversed in level flight 220 mètres in 21 seconds, rising to a height of about 5 mètres.

THE PRESSURE OF LIGHT (*p.* 90).—Experiments have now proved conclusively that a beam of light presses against any surface upon which it falls. Maxwell's calculation that the pressure on 1 sq. c.m. is equal to the energy in 1 cub. c.m. if the beam has been confirmed, so that we have a new force to be reckoned with. This is apparently of negligible account in terrestrial affairs; but out in the solar system, when there is no disturbing atmosphere, and when it acts without interruption for ages, it may produce very considerable results. Light pressure may account not only for the formation of comets' tails, if these tails are outbursts of finest dust, but also for the small bodies which appear to abound in our system, and to reveal their existence on any starlight night when perishing as shooting stars.

SYNTONIC WIRELESS TELEGRAPHY (*p.* 105).—Syntony, or tuning between transmitter and receiver, means the emission by the transmitter of sustained vibrations of definite frequency. Only when these are produced is it possible to employ in the receiver a circuit tuned or resonating to this particular frequency. The main difficulty with all methods of spark transmission is to produce these sustained vibrations. Mr. Poulsen has found that by burning the arc in an atmosphere containing hydrogen, by lengthening the arc and by placing it in a strong magnetic field, the frequency can be enormously increased and as many as a million vibrations a second may be obtained. The problem of syntonic signalling is at last nearing practical solution.

W. E. WARRAND.

RAILWAY GAZETTE.

November 9th and November 22nd, 1906.

NEW AMERICAN SIGNAL CODE.—The American Railway Signal Association has now published the result of its deliberations as to the arrangement of signals and their lights. It is a very comprehensive report, though extremely concise, and will no doubt be the subject of much correspondence.

The scheme propounded deals with, (1) the use of the three-position

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signal, (2) the indication by signals of instructions required for handling traffic.

As provision has to be made for train order signals (*i.e.* signals to train-men as to despatcher's orders) some indications are provided for which we have no counterpart in European practice.

The most important of the proposals are :—

1. Not less than two lights for any High Speed signal.
2. Distant signal to be abolished as a separate signal, the "Caution" position of a Home, Advanced, or Starting signal being used instead of the "On" position of a Distant signal.
3. The signals to be given in the upper right-hand quadrant, *i.e.* the signal to be raised instead of lowered.
4. Two lights arranged diagonally to the vertical as an indication of an auto-block-signal.
5. The lights are :—*red*, danger; *yellow*, caution; *green*, clear.

(N.B.—Caution is a warning position of the position of a signal ahead).

Day signals are to have two arms representing unlimited and limited (or medium) speeds; and also a low-speed arm, distinguished by being placed apart from the other pair; this latter is to have a dimmer light than the others.

The abolition of the Distant signal is really the most noteworthy of the proposals, the point being that a signal in the Danger position is never to be passed. The precise siting of the Home signals to sufficiently cover the train may, however, present some difficulty, particularly as in America the over-running of signals is a contingency which has always to be borne in mind.

C. E. VICKERS.

RIVISTA DI ARTIGLIERIA E GENIO.

October, 1906.

CONSTITUTION OF THE JAPANESE SIEGE CORPS AND PARK AT PORT ARTHUR.—It may be noted that, whilst the hostilities against Port Arthur commenced even before the declaration of war, on the night of the 8th—9th February, the effective operations for the investment and siege of the place were not commenced until June, after the disembarkation at Dalny and the organization of the IIIrd Japanese Army whose duty it was to constitute the Siege Corps.

This army was composed of 3 divisions (the 1st, 9th, and 11th), each containing 12 battalions (with 2 mitrailleuses to each battalion), 3 squadrons, 6 batteries of field artillery, and 3 companies of sappers. There was in addition an independent brigade of field artillery (12 batteries) and a regiment of siege artillery for service of the parks.

During the course of the operations 2 mixed brigades of reservists were added, so that the total strength of the Siege Corps amounted to about 70,000 men, constantly kept up to this number by reinforcements which continued to pour in from the mother country. This army was again increased by an entire division towards the end of the siege, and in November the 7th Division was also sent to Port Arthur. The strength of the Siege Corps then amounted to about 90,000 men.

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Dalny, a large and commodious commercial port, on the organization of which the Russians had expended several millions of roubles, became the base. This port, connected by railway with Port Arthur and with the Trans-Manchurian lines, was occupied by the Japanese a few days after the battle of Nansan on the 30th May.

The Commander-in-Chief of the Siege Corps was General Baron Nogi, descended from an old and noble race of Samurai, who enjoyed a reputation for great energy of character. His age in 1904 was 55 years. The hardships and responsibilities of the siege, and the grief caused by the loss of his two sons, both officers, had no effect in bending the strong fibre of his character, as was shown on the field of Mukden, where he gave splendid proof of will and energy.

The Japanese siege park made a progressive development during the extension of the operations; but in every way, even at the end of the siege, it was far from being in accordance with the latest requirements for such an organization.

At the commencement of the siege the park contained little more than a hundred cannon, heavy guns and those of medium calibre. There were 16 of 15-c.m. and about 50 of 12-c.m., and there were mortars of 15-c.m. and 9-c.m. and guns of 10·7-c.m. There were subsequently added about 30 marine artillery guns of various calibres (11, 12, and 15-c.m.) and several 15-c.m. and 9 c.m. mortars of old pattern. The most powerful of the guns was the 15-c.m., of which there were only two; but even these were not sufficiently powerful to cause damage to the Russian works, and it became necessary to send to Japan for 28-c.m. guns of Italian model. Towards the end of the siege the park consisted of about 200 cannon of medium calibre; but among these were several small calibre mortars and guns of bronze and of old patterns, which were of little importance.

The artillery of the attacking force was thus insufficient both in number and in weight of projectiles. There were wanting in the Japanese park some cannon of European siege park model, for example mortars of about 20-c.m. Moreover the 12 and 15-c.m. guns, which constituted the nucleus of the park, were not of modern pattern, and were undoubtedly inferior to those which (according to the critics of to-day) it is necessary to employ for the attack of an important fortified place.

One remembers the decisive successes obtained by the Japanese infantry in 1894, during the war with China, in the attack on the fortifications of Port Arthur, in which the same general Nogi had taken part with a brigade; and there would seem to have existed an inexact estimate of the value of the fortifications more lately constructed by the Russians. This may perhaps have been the reason for the neglect on the part of the Japanese commanders, during the preparations for the war, as regards the supply of siege artillery. In fact, General Nogi trusted in a great degree to the action of his admirable infantry, as was shown by the direction of the operations during the first months of the siege; for the slow and patient work of methodical attack was substituted a system of assaults by infantry in mass, a system which was certainly more rapid, but which, without a sufficient preparation by a powerful and numerous artillery, led to a useless sacrifice of life.

EDWARD T. THACKERAY.

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RECENT PUBLICATIONS.

The Russo-Japanese War. Compiled by the General Staff, W.O. Part I. (9½ × 6. 1s. 6d. Wyman).

The Battle of Tsu-shima, by Capt. V. Semenoff, one of the survivors, translated by Capt. A. B. Lindsay, with a preface by Sir George Sydenham Clarke, G.C.M.G.

Erfahrungen aussereuropaischer Kriege neuester Zeit: II. Aus dem russisch-japanischen Kriege 1904 bis 1905: 1. Port Arthur (*Heft 37/38* of the *Kriegsgeschichtliche Einzelschriften*), herausgegeben vom Grossen Generalstabe. (10 × 6½. Mittler, Berlin).

Studie über Ljaojau und Mukden, von J. R. Malczewski v. Tarnawa. (3·60 mks. Berlin).

Taktische Tagesfragen mit Rücksicht auf die Erfahrungen im russisch-japanischen Kriege, von Major Hugo Schmid, Generalstabskorps. (4 kr. Siedel, Vienna).

Campagne de l'Empereur Napoléon en Espagne, 1808—1809, par le Commandant Balagny. (12 frs. Berger-Levrault, Paris).

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89th	W. G. Bagot-Chester	4,115	190th	R. M. Aylmer	3,339
90th	A. G. Ottley	4,109	197th	O. Gough	3,262
93rd	A. P. Williams-Freeman	4,094	201st	P. W. J. A. Stomm	3,151
115th	D. M. Black	3,940	213th	B. W. Molony	2,881
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31st ... ... J. S. Barkworth 6,483

DECEMBER, 1905.

SECOND	H. G. MacGeorge	7,196	16th	R. Crofton	6,330
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FIFTH	H. A. Cox	6,967	54th	J. Kennedy	5,711

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MILITIA COMPETITIVE, MARCH, 1906.

A. E. Hardy	2,304	W. F. Anderson	1,947
N. H. Hutcheson	2,105	D. C. Robinson	1,879
F. D. Frost*	1,949	F. A. Bowring	1,876

*Read partly at the Army College, Aldershot.

ARMY QUALIFYING, 1906.

Nineteen passed.

Special Arrangements have been made for the Army Qualifying in next Examination.

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TACTICAL ORGANISATION.

By Capt. J. W. S. Sewell, R.E.

In the October, 1905, number of this Journal I endeavoured to analyse the principles of pure organisation. It was there pointed out that such principles placed a limit on the number of units in any one executive command.

It is now proposed to make an attempt to ascertain what exactly is the most desirable number of tactical units in any one command. This involves a brief survey of the principles of tactics.

These principles are as fundamental and immutable as those of strategy; but in their application to the requirements of the moment, it is always necessary to consider—

(*a*). The effect of the conditions of the period; such as destructive agents (arms, etc.), and modern scientific improvements (railways, telegraphs, etc.).

(*b*). The effect of local conditions; such as ground and the nature of the enemy.

The latter consideration must be given due weight on the spot by officers in executive command, when disposing their forces for battle: it cannot be allowed for in tactical organisation made beforehand in times of peace.

To give due weight to the former consideration is a duty in peace of the General Staff, who must evolve a system of tactics by applying such consideration to general principles. The resulting system must then be adopted for good or evil by the whole army, in order to produce that unison of action without which the skill of the greatest leader may prove fruitless.

In these days wars between civilised Powers are not sufficiently frequent to throw adequate light on the subject of the rapid changes in the effect of destructive agents. It is therefore almost inevitable that at the opening of a campaign the system previously evolved by the General Staff will require some modification. A large section not only of the Public, but also unfortunately of Officers who should know better, then becomes hysterical in its denunciation of the

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whole system ; and there is a tendency on the part of individuals to abandon discipline, and to adopt systems experimentally which are entirely at variance with fundamental principles. There is therefore not only urgent necessity that fundamental principles should be absorbed by every officer till they become part of himself; but there are also cogent reasons for the adoption of tactical organisations which, as far as may be possible, will render obedience to these principles difficult to avoid.

By the study of the series of actions constituting a campaign, it is possible to eliminate the local factors, and gain an insight into the general system of the commander. But to eliminate the factors arising from the conditions of the period requires deep thought and a serious study of the whole History of War. We turn then to the men who have made such study their lifework for a statement as to the residual Principles of tactics left after the elimination of local and periodic factors.

In Colonel Henderson's *Science of War* that deep student has pointed out clearly and forcibly that the greatest leaders of the British Army have attained success in the tactical field by their devotion to the "3-body" principle. But in the application of this principle the system has necessarily varied from age to age.

In the Peninsula War, the dispositions of Wellington were with three units in successive lines, and this system held good till the close of the 19th Century. The South African War showed, however, that the second line could not be brought up as a formed body to within decisive range ; whilst, if it was thrown into the firing line in waves in open order, the inevitable confusion of units of the first line was intensified to a dangerous degree.

The present system therefore arranges the two leading units in two parallel loose columns (instead of two successive lines), each unit dividing into first and second lines. The respective formations may be represented graphically thus :—

Each unit *A* and *B* being in its turn similarly formed in itself, it follows that the system may be regarded as one in which each command from the Army down to the company is composed of three bodies disposed in a triangle having its base towards the enemy.

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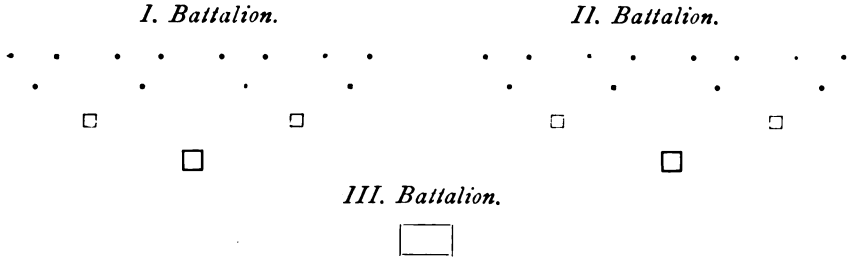
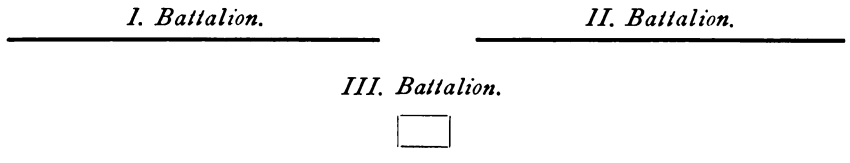
In fact, the ideal of the modern infantry attack may be represented generally thus :—



This formation gradually closes up to the final stage of one triangle :—



In defence the formation merely commences at a later stage than the first stage of the attack, but it embodies the same principle.

Thus the principle of disposing troops for battle so that each command is formed into three sub-commands remains as much our ideal to-day as in the days of the Black Prince or of Cromwell or of Wellington.

From the foregoing consideration there would appear to be a *prima facie* argument for the organisation of each command in three sub-commands.

Now let us consider existing organisations.

The Cavalry is organised into brigades each of three regiments, each of three squadrons. The squadron is composed of four troops, but the arguments for and against this arrangement are unknown to me.

With the Cavalry Brigade, as also with the Army Corps and the Infantry Division, are special troops ; but as these do not form part of the normal fighting disposition of these commands, they do not affect the argument in favour of the 3-unit system.

Field Artillery is organised into brigades of three batteries, each battery being composed of three sections.

Further, the moribund Army Corps consists of three Divisions, and the new Infantry Division is to consist of three Brigades—a great step forward, or rather back to the old British system.

In the lower commands in the Infantry we find the imprint of the Germanising ideas, which prevailed after the Franco-Prussian war, in organisations based on the idea of a 2-line system of tactics. For

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very forcible arguments against this system students of tactics may be referred to the pages of Henderson's *Science of War*. It is true that a 4-unit command may be disposed in accordance with the 3-line system to a certain extent by placing three units in parallel columns in first and second line ; but a reserve of one-fourth at the outset of an action is the absolute minimum permissible, and the alternatives are to break up a unit, which is obviously objectionable, or to have a reserve of one half, which entails most of the disadvantages of the 2-line system.

It is in fact difficult to make a sound disposition of a 4-unit command in accordance with the accepted principles of tactics ; whereas it is natural to dispose of a 3-unit command in accordance with those principles.

The objections to a 4-unit command apply in a considerably less degree to an 8-unit command. But the command in action of 8-units constitutes, as was shown in my previous article, a departure from the principles of organisation, which, as in the case of all departures from principles, can only be justified by exceptional conditions.

Let us imagine the 3-unit system carried out in its entirety. The brigade would revert to the 3-battalion brigade : each battalion would consist of 3 echelons, each of 3 companies : and finally each company would be formed of 3 sections.

As regards a company this involves no crucial difficulty ; and as each of the two sections in front line might be commanded by a subaltern, it would replace in the hands of those officers executive command which at the present day is only existent in theory.

The suggested organisation for a battalion involves no such radical change as might at first appear to be the case. No administrative change is necessary in peace ; but on mobilisation a ninth company must be formed of reservists. The administrative work of a company is so simple that it would be unnecessary to maintain the cadre of this company in peace.

Again, as regards the suggested 3-company echelons. These would be only tactical units, and no more administrative units than are half-battalions. As regards officers to command these units, there seems to be no just cause or impediment why the senior officer of a 3-unit body up to a battalion should not command the whole body and one unit as well—the unit in reserve of course : in the sister-service an Admiral commands the whole squadron and also one division of that squadron. So far then such an organisation would involve neither extra expense nor any radical change.

There remains the question of the brigade. Now, although it need hardly be any longer accepted as an axiom that the strength of a brigade must be the same as that of a German brigade, yet it would almost appear that as regards the brigade we have now become inextricably involved in the 4-unit organisation.

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The present war establishments provide two brigades of field artillery per (2-brigade) infantry division; which gives a proportion of about 4·5 guns per 1,000 bayonets, a proportion which, though smaller than the standard of some armies, is on the whole accepted as reasonable by most critics. But if the infantry brigade were reduced by one battalion, we must either have 3 brigades of artillery per (3-brigade) infantry division, giving a proportion of 6 guns per 1,000 bayonets, which would be too expensive; or we must have 2 brigades of artillery per (3-brigade) infantry division, giving a proportion of only 4 guns per 1,000 bayonets, which is lower than the permissible minimum.

If a remedy were sought by maintaining the war strength of a 3-battalion brigade at the same figure as that of the present 4-battalion brigade, it would be necessary to increase the war strength of battalions by one-third. To do this would entail either :—

(*a*). Increase of peace strength.
or (*b*). Increase of number of reservists rejoining on mobilisation.

Either alternative would practically involve an entire reconstruction of the organisation and distribution of the Infantry.

That the difficulties to be overcome in either case are very serious will not be denied by anyone who has studied the lecture by Major-General Miles on the Army System (see *Journal of the R.U.S.I.*, October, 1906). The problem may interest those who have time and talent for actuarial calculations based on a study of the statistics of the Adjutant General's department.

It thus appears that the prospective advantage of a 3-unit organisation for an Infantry brigade are probably weighed down by the grave difficulties of creating such an organisation; whilst the task of surmounting the disadvantages of a 4-unit system may be confidently left to the men selected to command brigades of British regular infantry.

It has, however, been a frequent experience of the Staff in past campaigns to be called on to organise, in the actual theatre of war, higher commands from a mass of units possessing no higher organisation than that of the battalion. When we consider the strength and distribution of the regular forces, and the organisation of the auxiliary forces, it seems probable that similar experiences await the Staff in future campaigns.

Let us hope that, when such occasions arise, circumstances will permit of the adoption of that 3-unit organisation which is as traditional in the British Army as it is sound in principle.

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*THE TOPOGRAPHICAL SECTION OF THE BRITISH GENERAL STAFF.**

IN continental armies the Topographical Sections of the Staff are responsible for the work which in Great Britain is divided between the Ordnance Survey and the Topographical Section of the General Staff. Our Topographical Section may be regarded as derived from the Ordnance Survey, though it was not formed directly from it and in the first years of its existence had no connection with it. The military side of the Ordnance Survey is apt to be lost sight of to-day, placed as it is under a civil Department of State, and a major portion of its work being cadastral rather than military. Its establishment was due to the need felt for an accurate map of the country for purposes of defence; and for upwards of 70 years it remained under the War Department, at one period being actually combined with the Topographical Section.

EARLY HISTORY.

After the rebellion of 1745 had been finally crushed at Culloden, Lieutenant-General Watson, D.Q.M.G. in North Britain, recognizing the necessity of having a good map of a wild and rugged region, which had been the scene of military operations and might be so again, directed Major-General W. Roy, R.E., then D.A.Q.M.G., to undertake the task.

This survey, afterwards extended to the Lowlands of Scotland, was not based on any great triangulation; but was more of the nature of a "magnificent military sketch" to quote General Roy's own description. The map was never completed, or published, the outbreak of the Seven Years' War in 1756 necessitating the employment elsewhere of the officers engaged upon it.

Although never completed, this survey is important as being the first large military survey undertaken in Great Britain and the forerunner of the Ordnance Survey. In that it marked an official recognition of the necessity of preparing maps of possible theatres of military operations, it may be regarded as the germ of an idea which more than a century later developed into a Military Topographical Department.

On the conclusion of peace in 1763 the question of undertaking a Topographical Survey of the whole of Great Britain came for the first

* Extracted from an account written by Capt. G. R. Frith, R.E., Staff Captain, T.S.G.S., by order of the Director of Military Operations.

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time under the consideration of the Government. Again war postponed the work, the outbreak of the American Revolution in 1776 turning the attention of the authorities in another direction.

With the advent of peace in 1783, General Roy thought the time favourable to bring forward once more the question of a national survey. Finding himself detained in London he conceived the idea of making a small trigonometrical survey of the immediate neighbourhood of the capital. As the foundation for his proposed survey he measured a base of 7,744·3 feet across the fields between the Jews Harp near Marylebone and Black Lane near Pancras.

General Roy's efforts were seconded from a totally unexpected quarter. In October, 1783, Comte d'Adhemar, then French Ambassador, transmitted to Mr. Fox, at that time Foreign Secretary, a memoir by M. Cassini de Thury, in which the latter showed the great benefit which would accrue to astronomy by carrying a series of triangles from London to Dover, and connecting them with those already executed in France, thus determining accurately the relative positions of the observatories of Greenwich and Paris. This proposal was communicated to the Royal Society, and, with the approval and financial assistance of the King, the task was entrusted to General Roy.

THE ORDNANCE SURVEY.

On the 16th of April, 1784, General Roy, accompanied by Sir Joseph Banks, President of the Royal Society, began operations for measuring a base on Hounslow Heath. The measurement of this base line may be called the commencement of the Ordnance Survey of Great Britain; though it was not till 1791 that, on the initiative of the Duke of Richmond, then Master General of the Ordnance, an order was given for a survey of the whole country for the purpose of producing a military map of the United Kingdom.

The establishment of a national survey having ensured the provision of accurate maps of the United Kingdom, an extension of the geographical service to include the colonies and foreign countries was the next requirement. In 1803 the value of a department which should collect information, both topographical and statistical, not only about Great Britain and her colonies but about foreign countries, appears to have been realized by the authorities.

THE DEPÔT OF MILITARY KNOWLEDGE.

The Department, which enjoyed the quaint title of Depôt (or Deposit) of Military Knowledge, was under the Q.M.G., but quite distinct. It appears that the office was divided into two branches, each under an "Officer of approved knowledge," one to have charge of the plans and maps and direct the drawing room, the other to have the direction of the manuscripts and library; in addition 2 D.A.Q.M.G.s were appointed to aid these officers, and there were 2 draftsmen and

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2 clerks. The work was retarded by the re-commencement of the war, and also by the lack of office accommodation. There seems to have been no co-ordination between the Depôt of Military Knowledge and the Ordnance Survey.

The long peace which followed the campaign of 1815, and the general lack of interest in military affairs consequent upon the final defeat of Napoleon, was felt by this embryo Intelligence Branch in common with the other departments of the army; and the outbreak of the war with Russia found the army quite unprovided with maps of the theatre of operations. The department created in 1803 had become a mere appanage of the Q.M.G.'s department; and the necessity of forming an entirely separate branch was brought home to the authorities through the persistent efforts of Major T. B. Jervis, a retired officer of the Bombay Engineers, who had throughout his service in India been employed on survey work and was an enthusiast in everything pertaining to geography and topography. In 1846 he addressed to Lord Aberdeen, then Foreign Secretary, a letter, pointing out the acknowledged want of geographical information in many well-known and recent cases and the want of a geographer attached to the Government and a national depôt of maps and plans. This memo. was acknowledged with thanks, but the stress of war was necessary to bring home to the Government the importance of a properly organized topographical department.

In 1854, at the outbreak of the Crimean War, Major Jervis was fortunate enough to obtain in Belgium copies of the Russian General Staff Map of the Crimea and the Austrian Military Map of Turkey in Europe, both very rare maps as they were jealously guarded by the respective War Offices. He transliterated the former and pressed the Government to have it reproduced for use in the field, but his proposal was not entertained. Undismayed by this rebuff he reproduced the maps at his own expense. At first the Government purchased but few; the map, however, was found so invaluable at the seat of war that large numbers were eventually bought.

THE TOPOGRAPHICAL DEPARTMENT OF THE W.O.

Major Jervis continued to press on the Government the importance of instituting a Topographical Department, and at last, on the 2nd February, 1855, was rewarded by receiving a letter from Lord Panmure, Secretary-at-War, notifying the sanction of the Treasury for the creation of a Topographical and Statistical Department in connection with the War Office, and offering him its superintendence.

In a memorandum to the War Department in 1855, Major Jervis gave his ideas as to the work which the department should perform :—

1st. Compilation and printing of all maps required for military and political purposes. Collection of maps published at home and abroad,

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and of topographical and statistical information about the colonies and foreign countries.

2nd. To afford facilities for a limited number of officers from all arms of the service to become acquainted with the methods employed in making and reproducing maps, and to acquire information both topographical and statistical about other countries.

3rd. To carry on geographical and statistical researches in other countries.

To carry out this last he proposed to have attached to the department, and under the orders of its director, a small number of highly-trained officers and subordinates, who should be constantly employed, in parties not exceeding six, in making maps of, and collecting information about, countries of which it might be considered desirable to gain accurate knowledge.

In August, 1855, there were employed in the department 26 engravers, lithographers, and assistants, including one clerk. In 1856, when the department moved to Spring Gardens, the amount taken in the estimates for it was £5,000. In this year it was decided by Lord Panmure that the duties of the department should embrace the acquisition of plans of all the barracks and forts in the British Dominions.

On April 3rd, 1857, Major Jervis died, and shortly afterwards a Committee was appointed by Lord Panmure to "investigate and report on the Topographical and Statistical Department." Pending their report Capt. J. Cameron, R.E., Executive Officer, Ordnance Survey, was placed in temporary charge of the department.

The Committee's report stated that, notwithstanding the zeal and ability displayed by Major Jervis, the value of the work was not proportionate to the cost and the selection of work not always judicious; and pointed out that there were three separate and independent establishments in connection with the War Office engaged in Topographical work, viz. :—

1. The Topographical Depôt of the Q.M.G.'s Department.

2. The Survey Branch of the Inspector General of Fortifications' Department.

3. The Topographical Department.

They recommended that there should be a department of Government for procuring topographical and statistical information, in which these three offices should be amalgamated, and that the officers of the department should be selected from as wide a field as possible. They considered that the department should be an independent branch of the War Office, and that the Secretary of State should be empowered to employ officers and men from any branch of the British or Indian Armies or from civil life. Also that the Ordnance Survey should be under the immediate direction of the Assistant Director in the Topographical Department.

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In consequence of this report Lord Panmure ordered the following arrangements to be carried out :—

(1). Lieut.-Colonel H. James, R.E., to be Director of the Topographical and Statistical Branch of the War Office, to include the Ordnance Survey.

(2). The existing Topographical Department, the Ordnance Survey, and the Topographical Depôt to be united.

(3). Appointment of four officers, additional to those of the Survey Department, to be selected from cavalry, artillery, engineers, and infantry.

(4). Pay to be £1,200 per annum for the Director, and for the other officers twice and one-half the regimental pay of their rank in lieu of all military pay and allowances.

(5). A quarterly return of progress to be rendered.

(6). Early attention to be paid to the study of colonial military resources.

Lord Panmure's instructions with regard to Colonial Surveys are of particular interest at the present time, when renewed efforts are being made to establish close relations with the Topographical Departments of the Self-Governing Colonies and to co-ordinate the various surveys of the Crown Colonies and Dependencies. In his letter of instructions to Colonel James, he said, "Lord Panmure is desirous that you direct an early attention to the subject of Colonial Surveys, ascertaining as far as possible what works of this nature are in progress at the expense of Colonial Legislatures, and reporting whether it may not be possible to establish a system under which your department, with the concurrence of the Secretary of State for the Colonies, may assist in their systematic prosecution, his Lordship being satisfied that, whether from a military, a scientific, or a national point of view, it is of much importance to bring all the topographical operations of the British Colonies into harmony with one another, and to collect all information respecting them at a central establishment accessible to government."

Subsequent to this report Major H. C. Elphinstone, V.C., R.E., was appointed to assist Colonel James as executive officer.

In April, 1858, the old Depôt of Military Knowledge, established in 1803 and latterly known as the Topographical Depôt of the Q.M.G.'s Department, was amalgamated with the Topographical and Statistical Branch.

In January, 1859, Major Elphinstone was succeeded by Major A. C. Cooke, R.E.; and in March of the same year Capt. Petrie of the 14th Regiment was appointed to the department in pursuance of Lord Panmure's decision to have each branch of the service represented.

In 1865 the Department was again subjected to the scrutiny of a Committee, consisting of:—Sir Richard Airey, K.C.B., Q.M.G., Colonel

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F. E. Chapman, C.B., D.A.G., R.E., Capt. D. Galton, R.E., Assistant Under Secretary of State for War. They were directed to enquire into the Topographical Department, especially with reference to the desirability of separating the Ordnance Survey from the Topographical Depôt. They recommended that no change should be made, but considered that there was a want of special supervision over the work done, and suggested :—

(1). That requisitions for military service should pass through the Q.M.G.

(2). That the sale of Ordnance maps should be transferred from the Topographical Depôt to two or four publishers in London.

The Secretary of State approved these conclusions, but reserved to himself the right of ordering any services he might think fit without reference to the Horse Guards.

In November, 1865, the necessity for extending the Topographical Department was discussed, and a project for its further development was laid before the War Office by Sir H. James, after approval had been given by H.R.H. the F.M. Commanding-in-Chief and by Sir John Burgoyne.

On the 1st April, 1870, the Ordnance Survey was transferred from the War Office to the Office of Works ; and in May, 1870, Capt. C. W. Wilson, R.E., who had been Executive Officer under Colonel James, was appointed Director of the Topographical and Statistical Department. The reasons which led to the severance of the Ordnance Survey from the Topographical and Statistical Department appear to have been financial and not difficulties of organization ; the military map of England and Wales being complete, it was not considered right that the cost of the cadastral survey should fall on the War Office vote.

During the directorship of Sir Henry James, a survey of Jerusalem and Sinai was carried out. This work was executed under the Ordnance Survey, and not, as would have been expected, by the Topographical Department.

It will thus be noted that for a period of 13 years (1857—1870) the two departments were under one director, an arrangement which enabled the Topographical Department to utilize the resources of the Ordnance Survey and thereby effect a reduction in its own staff of draftsmen and lithographers. During this period the Ordnance Survey printed for the Topographical Section 1,097 separate maps and plans, amounting in all to 237,519 impressions. A somewhat similar arrangement, so far as concerns utilizing the Ordnance Survey resources, still obtains, and tends greatly to relieve the strain on the Topographical Section under any sudden pressure of work.

When the Ordnance Survey was transferred from the War Office to the Office of Works, the Topographical Department consisted of but one officer (Lieutenant Baring, R.A., now Lord Cromer) in

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addition to the Executive Officer (Capt. Wilson, R.E.); the subordinate staff numbered 13 civil assistants and draftsmen, 4 labourers, and 1 military clerk.

The condition of the department at this time was not satisfactory. Besides the want of information about foreign armies the library and map collections were deficient. Reports from military attachés were seldom received. Officers were not sent officially to the Continent, and there was no information about the Colonies. The department was really in a transition stage; the statistical part was increasing in importance, and the whole branch needed re-organization.

THE INTELLIGENCE DEPARTMENT.

On the 30th April, 1870, Capt. Wilson submitted a memorandum on the state of the department and the duties it ought to perform. The topographical work was apparently hampered by insufficient funds being allotted for the purchase of maps. The recommendation of the committee of 1857 that "all maps now lying scattered throughout the offices of the I.G.F. and Q.M.G. should be added to the collection of the Topographical Depôt" had not been carried out; there were apparently some 4,000 maps in the Director of Works' Department alone, most of which were of a purely topographical character, embracing nearly every country in the world. The Statistical Branch of the Depôt also suffered from neglect. The whole department does not appear to have been taken seriously at this time, and would seem to have been regarded merely as an ornament which an army must have if it wished to be regarded as up-to-date. Capt. Wilson complained that when information on foreign statistics was required by the Secretaries of State or the heads of departments in the War Office, application was seldom made to the Topographical Depôt, the natural result being that officers gradually lost interest in their work. In the same report Capt. Wilson suggested that the War Office Library should be placed in charge of the Topographical Depôt.

When the war of 1870 broke out and the Government was in need of information about continental armies, it was apparent that a re-organization of the Department was urgently required, and Capt. Wilson prepared a scheme for this purpose in August, 1870. It is significant testimony to the practical value of such a department that its formation in 1855, its re-organization in 1871, and the large increase in its staff in 1904 should in each case have been brought about by war and the need, actually experienced, of information such as the department, properly organized and staffed, would supply.

Capt. Wilson's scheme, which was practically adopted in its entirety, was, briefly, for the department to be divided into two sections under one Director—a Topographical Section and a Statistical Section. The duties of these two Sections to be:—

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Topographical Section.

I. Collection of maps.—A collection to be formed of :—

(*a*). The best maps extant of Great Britain and Ireland, the Colonies, and all foreign countries.
(*b*). Plans of foreign fortresses.
(*c*). Maps and plans illustrative of campaigns, battles, sieges, etc.
(*d*). Photographs to be procured by purchase, exchange, and by encouraging officers who travel to send photographs to the Department.

II. Production of Maps.

(*a*). Compilation of maps for military purposes, such as that of Abyssinia issued before the departure of the expedition to that country.
(*b*). Copying maps.
(*c*). Lithographing maps.

Statistical Section.

This Section to be divided into three sub-sections, each presided over by an officer. Each sub-section to have allotted to it a group of countries, about which it would collect information of military value.

Capt. Wilson also recommended the formation of a good military library, to be placed under the Topographical Department.

In 1872 Capt. Wilson, at the request of Mr. Cardwell, S.S. for War, proposed a scheme for an enlargement of the department. The chief features of his proposals were :—

1. That an officer of high rank and position be placed at the head of the department, and have no executive duties.

2. That all candidates for staff employment be passed through the department, and thus become personally known to its chief.

3. That the system of working by sections be retained, but the staff increased.

4. That additional sections be formed for Home and Colonial defence, railways and telegraphs, and military history.

5. That a military periodical, similar to those published by continental armies, be issued by the department.

On the 24th February, 1873, Mr. Cardwell, in his speech on the Army Estimates, announced his intention of enlarging the department by transforming it into an Intelligence Department with a General Officer at its head.

On the 1st April, 1873, the Intelligence Department was created, and the Topographical Department allied to it, Major-General Sir P. MacDougal being appointed D.A.G., in charge of the combined offices.

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The general scope of the enlarged department was defined as :—

I. The collection of all statistical and topographical information which it would be useful to possess in the event of invasion or foreign war.

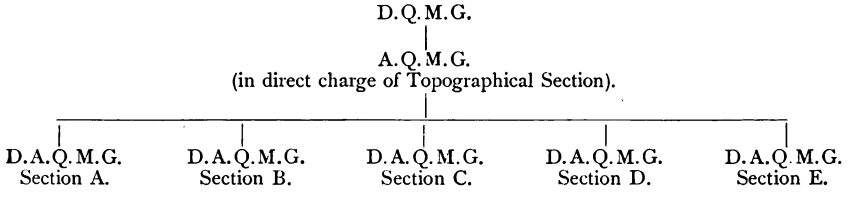
II. The application of such information, in respect to the measures, considered and determined on during peace, which should be adopted in war, so that no delay might arise from uncertainty and hesitation.

With the creation of the Intelligence Department, the separate existence of the Topographical Section ceased, and henceforth it constituted one of the branches of the department which had been evolved from it.

On the 2nd October, 1873, Major Wilson submitted to General MacDougal a scheme for a further enlargement of the Department, bringing the Ordnance Survey again under the chief of the Intelligence. The work of the suggested organization was to include the compilation of official accounts of wars and expeditions. The scheme was not adopted.

On the 22nd July, 1874, the Intelligence Branch was transferred to the Q.M.G.'s Department and Sir Patrick MacDougal was appointed D.Q.M.G.

In 1875 the following arrangement and distribution of duties was brought into force :—



In addition to directing the Topographical Section and exercising a general supervision over the five statistical sections, the A.Q.M.G. took Central Asia, China, and special subjects, as well as office routine work, registry, and general correspondence.

In March, 1876, Major Wilson's period of staff service expired and he left the department, being appointed head of the Ordnance Survey in Ireland. He was succeeded by Lieut.-Colonel R. Home, R.E.

THE TOPOGRAPHICAL SECTION.

In March, 1877, it was pointed out that the topographical work was so important that it was then executed under the immediate personal direction of the A.Q.M.G.; but that the many duties this officer was charged with did not permit him to give complete attention to this work. It was therefore considered advisable to form another section, and in October a new section, F, was added.

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The duties of the officer in charge of Section F comprised :—

Charge of map room and library.
Superintendence of compilation of maps.
Superintendence of lithographic work.
Issue of maps, plans, books, etc.
Selection of books and maps to be purchased.
Examination of newspapers and periodicals.

The staff of the Section consisted of :—
1 officer (D.A.Q.M.G.), 1 assistant librarian, 2 assistants to librarian, 5 draftsmen, 3 lithographers.

In 1894 the Library was constituted a separate Section. Otherwise the above organization was maintained till 1900, with little change except a small increase of staff. At the end of 1900 the strength of the Section was :—1 D.A.Q.M.G., 1 Staff Captain, 1 Attached Officer, 2 clerks, 1 map mounter, 1 map curator, 1 assistant do., 15 draftsmen, 1 photographer, 3 printers, 1 stone grainer.

In 1901 the whole office was rearranged, and Section F further reduced by being deprived of the custody of maps.

PRESENT ORGANIZATION AND DUTIES.

In 1904 the Intelligence Department was again re-organized, its designation being changed to that of Directorate of Military Operations. Under the new system it forms one of the branches of the newly created Department of the Chief of the General Staff, its immediate head being a Major-General with the title of Director of Military Operations.

The Directorate is divided into four sections, of which the Topographical Section forms the fourth. Under the re-organization the custody of the collection of maps has reverted to the section.

The present staff of the Topographical Section consists of :—

1 D.A.Q.M.G. in charge of the Section.
1 D.A.Q.M.G.
7 Staff Captains.
1 Map curator (civilian).
1 Assistant map curator (civilian).
3 Clerks.
1 Map mounter.
21 Draftsmen
1 Photographer
4 Litho printers } civilians.
1 Stone grainer
1 Boy

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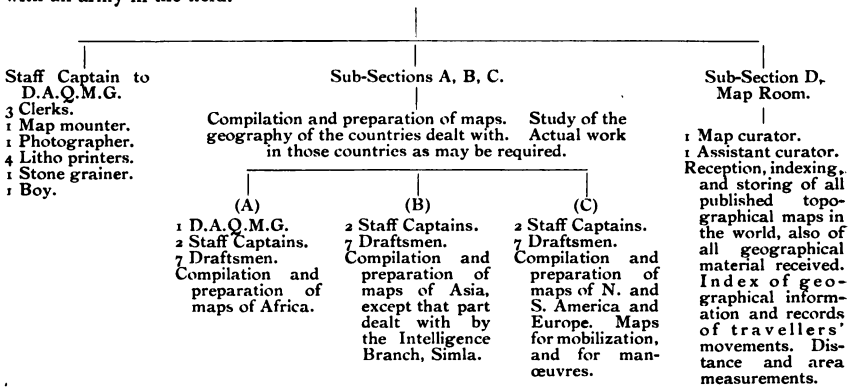
The organization of the Section is as follows :—

D.A.Q.M.G. IN CHARGE OF T.S.G.S.

Collection of topographical information, compilation and preparation of all maps for military purposes. Organization of all geographical work for the army. All matters connected with International boundary delimitation and demarcation commissions. Selection of officers for survey and geographical work. Issue of maps for war. Selection of officers from the Section, or who have served in the Section, for duty as Staff Officers for Topography with an army in the field.


Staff Captain to D.A.Q.M.G.
3 Clerks.
1 Map mounter.
1 Photographer.
4 Litho printers.
1 Stone grainer.
1 Boy.
Sub-Sections A, B, C.
Compilation and preparation of maps. Study of the geography of the countries dealt with. Actual work in those countries as may be required.
(A)
1 D.A.Q.M.G.
2 Staff Captains.
7 Draftsmen.
Compilation and preparation of maps of Africa.
(B)
2 Staff Captains.
7 Draftsmen.
Compilation and preparation of maps of Asia, except that part dealt with by the Intelligence Branch, Simla.
(C)
2 Staff Captains.
7 Draftsmen.
Compilation and preparation of maps of N. and S. America and Europe. Maps for mobilization, and for manœuvres.
Sub-Section D, Map Room.
1 Map curator.
1 Assistant curator.
Reception, indexing, and storing of all published topographical maps in the world, also of all geographical material received. Index of geographical information and records of travellers' movements. Distance and area measurements.

Broadly, the functions and duties of the Section are as follows :—

1. The provision of maps for war. This not only includes the compilation, arrangement, printing, and publication of geographical material in various forms for use by British troops ; it has been recently decided that officers of the Section should as far as possible have a personal knowledge of the countries with which they deal, and should themselves, as opportunities offer, take a part in the investigation of geographical problems on the spot.

2. The co-ordination as far as possible of the various survey organizations throughout the Empire. The Topographical Section of the General Staff is in fact the only co-ordinating element for geographical purposes in the Empire. The D.A.Q.M.G. in charge of the section is a member of the recently formed Colonial Survey Committee, which advises the Secretary of State for the Colonies on all matters connected with the surveys of the British Colonies and Protectorates in Tropical Africa.

3. All correspondence on technical matters between the War Office and the Ordnance Survey ; and on geographical matters between the War Office and the Intelligence Branch, Simla, and (through the latter) between the War Office and the Survey of India.

4. The Section advises the Foreign Office and the Colonial Office on all geographical questions, especially those connected with International Boundaries.

5. All questions relating to the appointment of army officers to geographical duties, and to the control of the Colonial Survey Section.

6. In war it has been decided that officers from the Topographical Section, or who have served in it, will be appointed Staff Officers to

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organize and direct the topographical work at the seat of war under the Chief of the Staff.

7. The drawing and printing of maps and charts for defence schemes.

8. Minor duties, such as the preparation of maps for handbooks and military reports.

THE ORDNANCE SURVEY.

At first sight the disproportion between the strength of the Topographical Branches of European War Offices and that of the Topographical Section of the British General Staff is very striking. A numerical comparison, however, is misleading, as much of the work done by the Topographical Departments of the French, German, Austrian, and Russian War Offices is in England carried out by the Ordnance Survey. In making any comparison therefore, the strength of the Ordnance Survey must be taken into consideration.

In 1905 the staff of the Ordnance Survey consisted of:—

23 Officers,
2 Warrant officers,
366 N.C. Officers and men,
1,630 Civil assistants,
535 Labourers.

A portion of the officers, N.C.O.s, and men, are organized into 3 Survey Companies, which form part of the Corps of Royal Engineers and are available as Fortress Companies in war. A considerable proportion of the civilians employed are men who have served in these Survey Companies.

Three complete Survey Sections, each composed of 2 officers and 12 N.C.O.s and men of the Royal Engineers, fully equipped both for survey work and for reproducing and printing maps, are held in readiness for service with an army in the field. Further, the whole plant, including 11 machine presses, of the large establishment of the Ordnance Survey at Southampton, is available for the production of military maps if required.

It will thus be seen that the survey staff available for service in the field during war, and the facilities at the command of the Topographical Section of the General Staff for reproducing and printing maps required for war, are very large, and should be sufficient to meet any probable demands.

PROGRESS OF SURVEYS IN BRITISH DEPENDENCIES.

Outside of Great Britain and Ireland and the Dependency of India, the survey work of the Empire is in a very backward state; but within the last two or three years steps have been taken which should ensure the eventual provision of good maps, sufficient to meet all military requirements, of Canada and of most of the African colonies.

In Canada a Topographical Section forms part of the recently created Intelligence Branch at the Militia Headquarters. This section is now engaged in executing a survey on a scale of 1 inch to

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1 mile. While the output of maps is at present small, owing to the limited amount of money available annually, no doubt as the value of the work becomes recognized, not only for military but also for civil purposes, the present small section will be developed.

In Australia nothing is being done towards executing a topographical survey of the country. In view of the vast extent of Australia and the small population, the commencement of such a survey can hardly be expected for some years.

The surveys and explorations of the British Colonies and Protectorates in Tropical Africa have developed very largely within the last few years. Briefly the state of the work is as follows :—

Gambia.—With the work of the various Boundary Commissions, and material collected by officials of the Colony, very fair maps are now available.

Sierra Leone.—An accurate survey of the vicinity of Freetown, on a scale of 1 inch to 1 mile, has been executed. Maps of the remainder of the Colony have been compiled from the work of Boundary Commissions and from route sketches.

Gold Coast.—An organized Survey Department has now been working for about five years. Accurate surveys of the mining area have been made, and a network of rigorous traverses run throughout the south of the Colony and Ashanti. Of the Northern Territories the only maps available are compilations from boundary maps and sketches.

Southern Nigeria.—In this Protectorate, which now embraces Lagos, regular surveys have been in progress for nearly five years, and fair maps of a considerable portion now exist. Under the new administration an amalgamated Survey Department is being formed, which will carry on a methodical survey of the country.

Northern Nigeria.—No attempt has been made to start a rigorous survey, and it is unlikely that any such survey will be commenced for many years. During the last year a small party, formed by agreement between the Colonial Office and the War Office, has accurately fixed by latitudes and telegraphic longitudes the position of fifteen points distributed over the Protectorate ; with the control furnished by these it will be possible to compile from route sketches and other material maps of sufficient accuracy to meet present requirements.

British Central Africa.—No systematic survey has been undertaken. In the South some rough plane table sketching is available, and in the North work executed by Boundary Commissions.

British East Africa.—A well-organized Survey Department has been formed and a systematic survey of the Protectorate is in progress, chiefly confined for the present to trigonometrical and cadastral work.

Uganda.—A Survey Department exists, which has made some progress with a network of secondary triangles. As a result of three Boundary Commissions a fair chain of triangles now extends from the Indian Ocean round the north of Lake Victoria to Lake Albert Edward.

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Somaliland.—The only maps of Somaliland are those compiled from surveys executed during military expeditions in the country and from the work of Boundary Commissions.

Egyptian Sudan.—An organized Survey Department has been in existence for several years, and excellent work is being done, but owing to the limited resources of the department and the vast area to be surveyed progress must necessarily be slow. At present cadastral surveys occupy most of the energies of the department.

South Africa.—The five South African Colonies form the area of British Africa of which it is most important to have good maps. In Cape Colony, Natal, the Orange River Colony, and the Transvaal, the geodetic framework has been completed, and arrangements have been concluded for completing the meridional chain of triangles already run through the greater part of Rhodesia.

In Cape Colony a staff of twelve officers is now engaged in executing reconnaissance surveys on a scale of 4 miles to 1 inch. This survey, while not of rigorous accuracy, should just fulfil the military requirements and can only be regarded as a temporary expedient.

In the Orange River Colony a Survey Section consisting of 2 officers and 4 N.C.O.s is engaged in carrying out a topographical survey.

In Natal, the Transvaal, and Rhodesia no topographical survey work has ever been carried out, and of these Colonies the only maps available are the untrustworthy ones compiled from farm surveys which proved of so little value during the Boer war.

Egypt.—In view of the preponderance of British influence in Egypt, and its geographical situation, that country may be considered with British Africa. A highly organized Survey Department forms part of the Egyptian Administration, and rigorous surveys of the country have been executed. Within the next year the Department expects to publish 140 sheets of the $\frac{1}{50000}$ map. A beginning is also being made with the geodetic lines along the Nile.

Other Colonies.—Of the remaining parts of the Empire few accurate maps exist. St. Helena, Bermuda, Mauritius, and Hong Kong have been accurately surveyed; but of the other colonies and dependencies only compilations from very rough material are available.

Until the last year no central body to co-ordinate and advise upon the survey work in progress in the various Crown Colonies existed. Recently an advisory committee termed the Colonial Survey Committee has been formed. This committee, which meets from time to time at the Colonial Office, deals with all questions of survey work, in the Colonies administered by the Crown, which may be referred to it by the Secretary of State for Colonies; it consists of a representative of the Colonial Office, the Director General of the Ordnance Survey, and the D.A.Q.M.G. in charge of the Topographical Section of the General Staff. Questions affecting surveys in Self-Governing Colonies do not, of course, come within the province of the committee.

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FERRO-CONCRETE COAL WHARF AT ROCHESTER.

By LIEUT. P. O. G. USBORNE, R.E.

A GENERAL description of the work now in progress for Messrs. Cory & Son, Coal Merchants, Rochester, appeared in *Engineering* (November 16th, 1906). It is hoped that the following details will be of interest to readers of this Journal.

The general design of the Wharf is by Mr. H. Shoosmith, M. INST. C.E.; and the reinforced concrete details have been worked out by Mr. L. G. Mouchel, M.S.C.E., agent for England of the Hennebique system. The contractors are Messrs. Playfair and Toole.

The site for the proposed Wharf is on the right bank of the Medway, in the immediate vicinity of Rochester Station (late S.E. Ry.). At this part the bank of the river is unused and unrevetted in any way; mud and grass flats form the foreshores. The rise and fall of the tide varies from 15 to 18 feet.

In order to cheapen the freight of coal, which is all sea-borne, Messrs. Cory & Son decided to construct a wharf on to which sidings from the S.E. & C. Ry. could bring rolling stock: this is the only reason for returning the ends of the Wharf (*vide* plan in *Fig.* 1). They also intended, by dredging the river bed immediately in front of the Wharf, to enable steamers to lie alongside.

The mud at this part is very soft and deep, and masonry, concrete blocks, or mass concrete were thereby put out of court as possible means of construction. Piling was obviously essential, and reinforced concrete makes the only permanent pile; its adoption was therefore decided upon.

Having decided on these preliminary details, trial holes were sunk on the site in order to determine the length of pile required and the nature of foundation to be got. It is believed that only two such borings were made, and their insufficiency has since been apparent.

About 30′ below Low Water Mark a hard bottom was found—supposed to be chalk, although at present no certainty of this exists. The piles were therefore designed of lengths varying from 37 to 41 feet. They have to be driven between half ebb and half flood tide; and must have 2′ 6″ at their upper ends left exposed for stripping and jointing to other members, both uprights and horizontals, *i.e.*, their heads should project about 6′ above Low Water Line.

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Along the front of the Wharf sheet piling is driven between the main piles, which are 16″ × 20″, up to the level of the waling. Behind this come two further rows of smaller piles. They are all connected together by horizontal waling at about 6′ above L.W.L. They are produced upwards by ferro-concrete verticals to the required deck level, viz. about 8′ above H.W.L., and their tops are connected together by cross beams, railbearers, and slab floor. The top is finished with 8″ of filling and 4″ of tarred limestone.

Diagonal bracing is introduced between piles all along the main front of the Wharf, where the shock of a ship bumping may be felt, but only occasionally along the returned ends.

The features of the work which appear most useful to the Royal Engineer may be summarized under the following two heads :—

(1). Reinforced concrete piling.
(2). Practical methods of construction.

EXCAVATION.

Now, in any particular work the length of the piles must be governed by the depth required in order to get a hard bottom. This has to be decided on, before moulding the piles, with sufficient accuracy to avoid much cutting away or jointing on afterwards.

For economy in handling, pitching, and driving piles should naturally be as short as possible. In this respect the tidal nature of the Medway is of great use, allowing short piles to be driven at low water, which can afterwards be lengthened as required. To make use of this advantage to the full it is necessary to clear away mud, soil, etc., from the proposed site almost down to L.W.L. The piles are then driven to a hard foundation during low water ; and if their length has been properly estimated, they should then project high enough above L.W.L. to allow of their heads being stripped of concrete and the reinforcement exposed, thus enabling the period between low and high water to be utilized for joining on the horizontal waling and producing the piles upwards as verticals.

For the Rochester Wharf no excavation was required along the front face, as the Wharf is being built well out into the river ; a little dredging (done at high water) has accomplished all that was required.

But at the returned ends, where the structure runs back into the bank, excavation had to be undertaken. *Fig. 2* shows a rough plan of the works as they are at present, with stacks of cast piles ready for driving : on the right hand is shown the approximate amount of digging that had to be done.

When this excavation was started, the contractors thought that they could cut straight down, 20 to 30 feet, leaving a vertical face of mud

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only 4 feet behind the inner row of piles. The earth excavated was thrown back on the top of this vertical mud bank. They did revet the face with light timber sheeting; but when their pile driving was well in progress the mud slipped, burying all their gear and necessitating fresh excavation.

As is well known, once slips have started they require drastic treatment to stop them. An expert in these matters from similar works at Southampton came to inspect the place, and advocated cutting the mud back from a vertical face to a flat slope of 1 in 2. Naturally the contractors were very loth to do this; but after another slip it became obviously necessary, and was done. Accidents of this kind, easily avoidable in themselves, cannot be considered as creditable; nor do they pay.

It is worth while noting that excavations on tidal foreshores should be accomplished by dredgers or grabs at High Water. At Low Water the soft wet mud offers no footings or facilities for mechanical navvying; and usually the spoil thrown out has to be loaded into lighters or barges, either by hand or by grab, involving two handlings.

STAGING.

When the above excavation was complete, staging formed on timber piles had to be erected. At the Rochester site some remains of old wharves existed: one of these was set aside for landing timber, ballast, cement, etc., which all come by water; the other served as staging for pile drivers. But a good deal of additional staging on timber piles was required, and these piles were driven from lighters floated in at high water.

The positions of all angles and also all alignments were fixed by transit lines, these lines being laid out by erecting accurate marks in line on shore.

PILE DRIVING.

When piling began, a start was made on both the inshore ends of the Wharf; and as these piles were driven the temporary staging, with the pile drivers, was moved further out by the help of the lighters.

The ferro-concrete piles were brought out on the staging on rollers by hand. They were pitched in the usual manner, and driven with a dolly or cap placed over their heads. At Southampton a sawdust cushion was used between the head of the pile and the dolly; but this has not been considered necessary here.

After all the piles had been cast, and piling was well in swing, the mistake of too few trial holes was discovered. The underlying hard foundation (chalk) was found to be at very variable depths. Some piles would go through the mud very rapidly, and strike the chalk

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when 10′ was still projecting above L.W.L. To drive them much further was useless; and the only remedy was to strip some 10′ of concrete off their tops, exposing the steel. This was necessary to enable the horizontal waling to be joined in at the proper level: cutting with a cold chisel and hammer is the only way to do this, and it is a very tedious and lengthy process if the pile has been well made.

Other piles were driven out of sight without touching the hard. The remedy for this is to join on an extra length. *Fig.* 3 illustrates the method of doing this. The reinforcement of the pile is bared for 2′ 6″. A cylindrical ferrule, 10″ long, is slipped over the top end of each steel rod and held in place by steel wire. The lower ends of the steel rods for the extra length are similarly inserted in the ferrule from above. Then short steel splicing rods, 5′ long and of the same diameter as the reinforcement, are used to fish the joint, being laced by steel wire to the rods of the reinforcement. Sheeting is then fixed, and concrete is packed in to the height required, being formed into a driving head at the top. This concrete has to set for six weeks before driving may be continued.

It is therefore clear that a small number of trial bore holes is not always an economy.

On going through mud the point of a pile may strike an obstruction, such as a sunken baulk of timber, which will deflect it. In such a case it is usually best to draw the pile at once. It is rarely that exact alignment will be obtained by slewing the head of the pile over, and trying to drive it back into its correct position. If circumstances permit, float a lighter alongside the pile and make fast to it at Low Water; the rising tide will then do the work.

One pile has been broken on the Rochester works, apparently about 10′ below the mud surface; it has not yet been drawn, and so further information is not available.

There are four pile drivers on the works, two heavy and two light. A sketch of the heavier one is given in *Fig.* 4.

The frame of such a pile driver took four carpenters fourteen days to make, or about 448 man-hours, costing in England £15. This does not include any material or the fixing of machinery.

PILE CONSTRUCTION.

The main piles and sheet piling in this Wharf are all of ferro-concrete.

The sheet piles are 30′ long, being shod with the usual splayed cast-iron piling shoe. They have a semi-circular rebate down both sides. When in position, the cylindrical hole formed by two adjacent rebates is filled up with cement, put down in a long canvas bag. It seems doubtful whether a watertight joint could ever be

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obtained by this means; it would appear to be better to pour a strong mortar, made with quick-setting cement, in fairly liquid form down the hole, ensuring that the whole joint was filled by lightly ramming with a long pole.

The main piles are of various sizes. The largest are 16″ × 20″. These are used along the front of the Wharf and are 41′ long, being cast with a hollow in the centre (*Fig.* 5). The armouring consists of four bars of $1\frac{3}{8}$″ round steel. At the toe these terminate in four holes in a pointed cast-iron shoe, which has four wrought-iron straps, turning inwards into the concrete, to hold it in position.

The four steel bars are kept apart by cast-iron distance pieces, spaced 4′ apart (*Fig.* 5), and are held together by links of steel wire, about No. 3 gauge ($\frac{3}{16}$″ diameter). These links are placed 6″ apart along the middle of the pile, closing up to 3″ and 2″ spacing at the bottom and top respectively.

The hollow in the middle of the pile is formed with thin sheet iron cylinders, 4′ long and 8″ in diameter, placed between the cast-iron distance pieces.

Fig. 6 shows a section through the casing for a pile. The sides are held together by wood cleats nailed to them on top, and the reinforcement is held up by clips over these cleats. The tops of the clips can be knocked outwards or inwards, thus raising or lowering the reinforcement, which must be adjusted very carefully to the casing.

Other sizes of piles in use are:—16″ × 16″, with $1\frac{3}{8}$″ reinforcement, averaging 37′ long; and 14″ × 14″ with $1\frac{1}{4}$″ steel, also about 37′ long. These are all solid, the 16″ × 20″ piles along the front being the only hollow ones.

The amount of steel in piles varies from $2\frac{1}{2}$ to 5 per cent. The 16″ × 20″ hollow piles and the 16″ × 16″ solid ones in the Rochester Wharf have about $2\frac{1}{2}$ per cent. of steel only.

This can in no sense be considered as anything more than a general guide. Mr. Mouchel says that he never designs piles with any reference to percentage, but simply as if they were beams, assuming that they have to be handled very roughly and will be placed in various unexpected positions. In short, formulæ for the accurate design of piles are still the property of experts, and for important structures experts should be consulted. For ordinary piles the $2\frac{1}{2}$ to 5 per cent. rule is a good guide, provided that the length does not exceed 30 times the least breadth of the pile (16″ × 16″ piles are used up to 40′ long).

The gauging of the concrete for the piles is the most important part of their construction. The ballast used at Rochester is Thames ballast, and is carefully screened to separate out the sand. Rounded sand and ballast is preferred, as it is easier to gauge the interstices and prevent porosity. The screened ballast is broken to a $\frac{7}{8}$″ gauge, and

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then 1 yard of ballast and ½ a yard of sand (by volume) are mixed with 7 cwt. (by weight) of cement. Water is added as considered desirable by the contractor—with this one proviso, that the whole of the above mixture must ram into 31 cub. ft.

This becomes impossible if too much water is used. The practical manner of checking this is to cast five or six piles at one time. The quantities for the concrete are roughly worked out beforehand, and if more than a barrow full of concrete remains over at the end, the mixture is too wet. Of course it is then too late to alter these piles, but the representative of the firm of reinforced concrete specialists, whoever he may be, can tell fairly well by experience how the mixing is being performed.

The piles are cast in a horizontal position. Until recently it was considered necessary to mould piles in a vertical sheeting; but now this is never done, as experience has shown that there no material advantage is gained thereby. Enough men and material must, however, be got together to enable a pile to be finished in one operation.

The concrete must be very carefully mixed, by hand, close to the work. It is carried to the casing in small buckets or cans, and there deposited in position. It has to be very carefully rammed or packed, so as to make it properly fill the casing underneath the reinforcement; to ensure this in the case of hollow piles, which are particularly difficult to pack, the first lot of concrete put in may be slightly wetter than the rest. The ramming is done with light pieces of timber, and is really better described as "poking" or "packing" into position.

For solid piles, or waling, etc., the filling is begun from one end and carried on towards the other, the face of the concrete at any instant being the natural slope of repose of wet concrete.

All piles are specified to set for six weeks before being driven.

The top of a pile, when ready for driving, has 3″ of plain concrete above the reinforcement.

In the foundations of a new warehouse at Victoria Docks, ferro-concrete piles cost about 4s. 6d. per cubic foot to make and drive.

Major E. Stokes-Roberts, R.E., in a "Report on the Application of Reinforced Concrete," published in India, says that he has seen a 35′ ferro-concrete pile, 15″ × 15″, driven through a 12″ slab of concrete, which it was not thought worth while to go to the expense of removing.

WALING, DIAGONALS, AND SUPERSTRUCTURE.

In the design of a Wharf or of any other structure carrying rails and rolling stock, the first thing is to locate the permanent way on the plan, remembering that curves may be sharp since the speed will always be slow. When this is done, place reinforced concrete beams or rail bearers under the rails. These will in turn be supported by

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cross girders running from pile to pile, transversely to the direction of railway line. The whole surface is closed in by a slab floor.

In the Rochester Wharf there are two railway tracks and a crane track to be allowed for, and the test loads are specified as follows.

Crane Track (main wharf).

Outer rail—100 tons on 3 wheels, base 22′ 6″.
Inner rail— 50 tons „ „ 22′ 6″.

Railway Tracks.

All tracks— 30 tons on 6 wheels, base 9′ 0″.
„ „ or 20 tons on 4 wheels, „ 6′ 0″.
„ „ or 25 „ „ 9′ 9″.

The calculations for a rail bearer and cross girder are given at the end of this article.

Fig. 7 shows a section of the rail bearers, and *Fig.* 11 shows the cross girders, as designed by Mr. Mouchel.

The rails are laid on longitudinal sleepers, placed immediately above the bearers and sunk flush with the deck surface. There is 6″ of stone packing between the sleepers and the bearers; this helps to distribute the wheel loads over some 2′ or 3′ of the bearers, giving a slight reduction of bending moment.

The slab floor is 6″ thick, with $\frac{1}{2}$″ armour placed as shown in *Fig.* 7. There is also $\frac{5}{16}$″ transverse armour along the top, about 3 bars per foot.

At the water face, it will be noticed (*Fig.* 8) that the main horizontal beam is placed immediately under the outer crane track, while the front edge of the floor is finished with another and lighter beam.

Down the front of all uprights along the face of the front wall of the Wharf are secured timber rubbing pieces. These are 8″ × 11″ green-heart, protected with a segmental wrot-iron strap, 5″ × $\frac{3}{4}$″.

The construction of the superstructure of the Wharf is not a matter of much difficulty.

After the piles have been driven to their required depth, the concrete is stripped from their heads, exposing at least 2′ 6″ of reinforcement; if the pile has not been driven deep enough, and overmuch is projecting above proposed level of waling, more cutting away is required.

The sheeting for the waling, which is 14″ × 14″, is then fixed in position; it is left open at the top and the reinforcement is laid in it. The waling is not subject to any serious cross-breaking strain; its purpose really is to brace the whole structure, and to take direct tension or thrust when vessels come alongside the wharf and bump into it. The reinforcement is therefore laid longitudinally and

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straight. It is kept apart by short cloven iron bars (shown in *Fig.* 9), placed diagonally, and held together by links of $\frac{3}{16}$″ steel, just as for the piles but spaced 6″ apart. The reinforcement in the waling and diagonals consists of four 1″ bars.

At the same time as this sheeting is being placed, the vertical casing for the upright prolongations of the piles must be fixed. For purposes of filling and ramming, it must be left open on one side. Three sides are therefore formed of boards running vertically; and the fourth is closed up by short horizontal boards, 2′ at a time, as the work of filling and ramming progresses upwards. The reinforcement is fixed in position in the usual manner. The number of twisted ties or links required is not so large as in the case of the pile proper; where the shock of driving has not to be contended with, 6″ to 8″ spacing is therefore sufficient for these.

At their lower ends the vertical steels are attached to the bars of the pile with ferrules, just as for lengthening a pile, the only difference being that the 5′ splicing rods are not required.

The horizontal walling is joined to the pile by passing its reinforcement bars from both sides through the reinforcement of the pile, so that the bars overlap each other about 2′. The detail of the joint is shown in *Fig.* 10. It will be noticed that the joint is not made plain square; but that additional adhesion is obtained by splaying out the concrete joint, and also a considerable amount of increased stiffness by introducing short $\frac{1}{2}$″ diagonal steel bars. This treatment of joints is adopted throughout the whole structure.

The concrete for the waling has to be laid during half tides.

When the water recedes it leaves all old work covered with a film of mud. This is cleared away with a hose pipe, and the surface of the existing concrete is chipped and roughened with cold chisels before any more laying can be done. The concrete is mixed close to the work and is carried down in small buckets, being carefully placed in position and rammed, as for the piles. All the aggregate is gauged to $\frac{7}{8}$″ throughout. The top of the waling is smoothed off by hand with a straight edge, and covered with sacks to prevent detrition when the tide rises again.

When the uprights have been made and setting is complete, the casing is removed; and then there remains only the floor to put in.

The sheeting for cross girders, railbearers, and floor is all made in one. The reinforcement and stirrups are carefully placed, and the whole is laid as a monolith. The vertical bars of the uprights are flattened or bent over, and terminate about 3″ below the finished floor surface. The reinforcement of the floor is shown in *Fig.* 7; it consists of $\frac{1}{2}$″ bars, straight and bent alternately, spaced 4 to the foot, while $\frac{5}{16}$″ bars, spaced 3 to the foot, are laid transversely at the top of the slab. The floor slabs are considered as continuous across the railbearers.

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In all works of this description one of the most expensive items is always the timber sheeting. In this respect a good foreman is invaluable, as he can save an enormous amount of cutting to waste, and can so make up his sheeting as to readily admit of using it over and over again. $1\frac{1}{2}''$ to $2''$ deal boards are used throughout at Rochester.

At the land face of the Wharf, a little extra deck space is obtained by giving a cantilever overhang. This is shown in *Fig.* 8 and needs no explanation.

LABOUR AND SUPERVISION.

While tide work is in progress the men are paid time and a quarter, whether they work night or day. They are also supplied with sea boots for working in the mud.

The supervision seems to be insufficient. It has actually occurred on this work that some of the reinforcement specified has not been put in; this may be due to many causes, but it is manifestly impossible to expect uneducated workmen, or even foremen, to understand the somewhat complicated drawings of reinforced work. The method resorted to for ensuring accuracy is to lay out the reinforcement for any member all together on the ground beforehand and label it. This tends to eliminate mistakes.

It was found to be a very difficult and tedious job to cut away all the concrete from those members in which part of the reinforcement had been left out, and the only remedy is constant supervision. If it is permissible to criticise these works further, it appears that the piles have all been cast unnecessarily far from their eventual site, involving much labour in shifting (see *Fig.* 2), and that some sort of workmen's club or shelter might have been provided with advantage.

It is noteworthy, too, that, as the piles have got to be set for six weeks, and the rate of driving is necessarily slow, there is nothing to be gained by manufacturing piles faster than they can be driven. The first stages of the work must therefore necessarily be slow, and the number of men employed should not be large.

The lighting for night work is done by three Wells lights, a special man being kept on the works for their superintendence.

PATENT RIGHTS.

In considering the practical methods of construction, the primary question of interest is—How far do patent rights affect us?

In civil practice in England, some engineer designs the general plan of the work, and then goes to a specialist, such as Mr. L. G. Mouchel, to design the reinforcement details, both of these receiving a fee for their work.

The contract is then let, and the accepted contractor must pay a license of £500 to the particular firm on whose reinforced system the

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structure is being built. Sometimes, also, he has to pay a certain commission on the total cost of the work.

When work commences, the firm of reinforced concrete specialists are bound to oversee the work, standing practically in the position of an architect so far as the reinforced portion is concerned.

But no patent rights can prevent any individual or collection of individuals from using any device whatsoever for their own work.

Government is therefore entirely at liberty to use the Hennibique or any other system of reinforced construction in England, provided that War Department labour is employed. If, however, a contractor be employed, complications arise, and it is difficult to say what the final legal decision might be in such a case if the Patentees protested. In practice it would be simpler and better to call in the firm of specialists and pay their fee.

But the matter is different abroad. In India or S. Africa, for instance, few, if any, reinforced concrete systems are protected, and we have an absolutely free hand.

It is the first business instinct of all civil firms to create a mystery enshrouding their particular work; and while pretending that they possess information of very far-reaching importance, to veil it with the utmost care. At the same time a little thought and some experience will convince anyone that there is a very large proportion of bluff. Such firms of specialists have experience galore; but drawings of every existing reinforced structure can be got for reference, and one or two simple formulæ will supply us with all that economical practice demands.

CALCULATIONS FOR RAIL BEARERS.

The span of the bearer is 10′.

A careful inspection of the three test loads given on page 86 shows that the largest bending moment is produced by the 25-ton engine on 4 wheels with a base of 9′ 9″, when one axle is right over the centre of the bearer, and

$$\text{this Moment} = \tfrac{125}{8} \text{ ft. tons} = 35{,}000 \text{ ft. lbs.}$$

The weight of the bearer itself is negligible, also that of the superincumbent load due to people, etc.; but the weight of the floor must be considered.

The thickness of concrete is 6″, weighing 112 lbs. per ft. cube, or 56 lbs. per ft. super. The weight of ballast and limestone, 12″ deep, may be taken at 130 lbs. per ft. cube, or 130 lbs. per ft. super. Total 186 lbs., or say 200 lbs. per ft. super.

Each bearer (*Fig.* 7) appears to support a slab of floor

$$10' \text{ long by } \frac{5'\ 2\frac{1}{2}''}{2} + \frac{4'\ 11''}{2} \text{ wide} = 50 \text{ sq. ft. nearly.}$$

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Therefore the total dead load $= 50 \times 200$ lbs. $= 10{,}000$ lbs.
Then for this uniform load

$$M_f = \frac{Wl}{10} \text{ (since the bearer is continuous)} = \frac{10{,}000 \times 10}{10} \text{ ft. lbs.}$$
$$= 10{,}000 \text{ ft. lbs.}$$

Therefore total $M_f = 45{,}000$ ft. lbs. $= 540{,}000$ inch lbs.

And
$$M_f = M_r = \tfrac{1}{6} r_c \, bd^2 = 540{,}000$$
$$\therefore \tfrac{1}{6} \times 600 \, bd^2 = 540{,}000$$
$$\therefore bd^2 = 5{,}400.$$

(Safe resistance to crushing of concrete may be taken as 600 lbs.).
Now by ordinary rules for T beams B, the effective breadth of the top of the tee, may be taken as half the spacing of the beams (*Fig.* 12).
Therefore

$$B = \frac{5' \; 2\tfrac{1}{2}'' + 4' \; 11''}{2} \div 2 = 30'' \text{ nearly.}$$

The compression portion of the tee is represented by the rectangle *wxyz* and the pressure is assumed to be uniform throughout it;

and the effective depth of the section is $d^1 + \frac{g}{2}$.

Therefore in the above formula, where it was found that $bd^2 = 5{,}400$, we can substitute B, or 30″, for b.

$$\therefore d^2 = \frac{5400''}{30} = 180''$$
$$\therefore d = 13\tfrac{1}{2}''.$$

But
$$d = d^1 + \frac{g}{2} = d^1 + 3'' \text{ (since } g = 6'')$$
$$\therefore d^1 = 10\tfrac{1}{2}''.$$

Allowing $1\frac{1}{2}''$ for covering the reinforcement, the final depth of the rail bearer below the floor slab becomes 12″; or, adding in the thickness of the floor slab, the total depth of the rail bearer is 18″.

1 per cent. of steel may be used for such beams, the percentage being based on the area of the tee head. 1 % of $30'' \times 6'' = 1{\cdot}8$ sq. ins. Two bars $1\frac{1}{16}''$ diameter will therefore suffice.

On referring to *Fig.* 7, it will be seen that Mr. Mouchel has used a beam only 16″ deep and having two 1″ bars as reinforcement. Our formula errs therefore very slightly on the safe side.

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The thickness of the T beam at its stem (*b* in *Fig.* 12) is usually made $\frac{1}{6}$th of B. This thickness is governed solely by the tendency of the tee head to shear off from the stem, and is based on practical experience. In this case 5″ would suffice, but 6″ is used.

CALCULATIONS FOR CROSS GIRDERS.

The cross girders (*Fig.* 11) are 10′ apart, and their span is 13′ 10″ or 14′, centre to centre. They are continuous over a central support, and may be considered as fixed at their ends.

All dead load may be treated as concentrated at the junctions of the rail bearers to the cross girders.

The dead load on one span, due to the 6″ floor,

$$= 14' \times 10' \times \tfrac{1}{2} \times \frac{112}{2240} = 3{\cdot}5 \text{ tons.}$$

That due to the bearers, at each point of application,

$$= \frac{16'' \times 6''}{144} \times 10' \times \frac{112}{2240} = {\cdot}35 \text{ tons.}$$

That due to the cross girder itself

$$= 14' \times 1' \times 2' \times \frac{112}{2240} = 1{\cdot}4 \text{ tons.}$$

Therefore the total dead load at each point where the junction with rail bearers occurs may be taken as

$$= \frac{3{\cdot}5}{2} + {\cdot}35 + \frac{1{\cdot}4}{2} \text{ tons} = 2{\cdot}8 \text{ tons.}$$

In addition to this there is the live load of an engine on each track.

Consideration will show that the first engine quoted in the test loads, namely 30 tons on 6 wheels with base 9′, will produce the greatest stress in the cross girder when standing with its centre axle immediately over the cross girder and its leading and trailing wheels resting on the adjacent rail bearers. When in this position it brings a load of 10·5 tons on to the cross girder at each junction with the rail bearers, partly direct and partly transmitted by these bearers.

Therefore the total load on the cross girder is $10{\cdot}5 + 2{\cdot}8 = 13{\cdot}3$ tons under each rail, as shown in *Fig.* 13.

In this figure the diagram of bending moments is drawn to scale. When measured it shows the maximum M_f to be about the support and equal to 500 inch tons, and also that the maximum downward M_f in the central portion of the beam is only 270 inch tons.

It will be noticed that the load due to the outer crane track has been ignored; its effect on the cross girder is practically *nil*, since

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it falls immediately above a splayed joint and a diagonal brace, and only 10″ from the pile head itself.

Having found the M_f all that remains is to design the girder. The usual formula for beams can be used, taking the safe resistance of concrete to compression as 600 lbs.

(1) First for the middle portion of the beam.

From diagram,

$$M_f = 270 \text{ inch tons} = M_r$$

$$= \frac{I}{6} r_c b d^2$$

$$= \frac{I}{6} \times 600\ bd^2 \div 2240$$

$$\therefore\ bd^2 = \frac{270}{600} \times 6 \times 2240 = 6048.$$

Assume $b = 12''$. Then

$$d^2 = 504$$

$$\therefore\ d = 22\tfrac{1}{2}''.$$

Allowing $1\frac{1}{2}''$ for covering reinforcement, the total depth of beam $= 24''$.

The usual allowance of steel is 2 % for beams.

The cross section of concrete $= 24 \times 12$ sq. ins. $= 288$ sq. ins.

$$\therefore \text{ area of reinforcement} = 5{\cdot}76 \text{ sq. ins.}$$

Assume 4 bars. Then section of each $= 1{\cdot}44''$.

$\therefore$ four $1\frac{3}{8}''$ bars will do. Mr. Mouchel uses four $1\frac{1}{2}''$ bars.

Where the M_f changes from sagging to bogging, two of these bars are bent up in the usual manner.

(2) Over the central support, or pile, the $M_f = 500$ inch tons.

Here again

$$500 = M_f = M_r = \frac{I}{6} r_c b d^2 = \frac{I}{6} \times 600\ bd^2 \div 2240\ ;$$

$$\therefore\ bd^2 = 11200.$$

Again assume $b = 12''$. Then

$$d^2 = 933$$

$$\therefore\ d = 30\tfrac{1}{2}''.$$

Allowing $1\frac{1}{2}''$ for covering the reinforcement, total $d = 32''$.

This large depth required is met by shouldering out the head of the pile as shown in *Fig.* 8. The shoulder in this case is made $12''$ deep, giving a total beam section of $12'' \times 36''$.

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Reference to *Fig.* 13 will show that the M_f falls very rapidly as we get further from the point of support, and reaches the value of 270 inch tons at 14″ from the centre of the support. The shoulder must therefore extend at least 14″ from the pile centre; but, since the pile is 16″ × 16″, the shoulder need only project 6″ beyond the pile.

In this case (*Fig.* 7) it is made to project 12″; and it is reinforced on the compression edge against shear and other stresses with two ½″ bars similar to those in *Fig.* 10.

It must be remembered that the 1½″ steel bars, which remain at the bottom of the beam all the way over the point of support, help to resist compression, though no account has here been taken of them.

Also that, when one span of the cross girder is loaded and the other not, the whole of one girder may be under an upward bending stress, while the other is much more severely strained in a downward direction than *Fig.* 13 shows.

For this reason two 1″ bars are introduced along the top of the cross girder, in order either to take tension or to assist with the compression.

The steel allowed at the top of the beam above the point of support is just 2%.

NOTE.—The author regrets that space has not allowed a fuller investigation of the methods of calculating continuous beams of this description. The whole subject is a very lengthy and difficult one.

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MEMOIRS.

LIEUT. F. H. BUSHELL, R.E.

THE past year has been a disastrous one for the Corps in India. Amongst the names of the comrades, whose loss we have to deplore, occurs that of Frederick Harley Bushell, a keen and energetic soldier, a thorough sportsman, and an all-round favourite, who died of enteric at Bangalore on October 31st.

Born in 1878, Bushell was educated at Harrow, entering "The Shop" (where he obtained his "Colours" for Association Football and Revolver Shooting) in January, 1896, and gaining his commission in December, 1897.

Soon after arrival in India in 1900, he was posted, as he wished, to the Sappers and Miners, and fell to the 2nd "Queen's Own." After undergoing an 18 months' course in the Civil Telegraph Department, and serving a year in Chitral with the 14th Company, he was selected for the command of C Company, which embraces the Telegraph, Printing, and Photo-Litho Sections of the Corps.

His selection was amply justified by the manner in which he threw himself heart and soul into his job, with that sturdy self-reliance which was his main characteristic, raising the efficiency of the various Sections and making for himself a name as an Army Telegraph expert, of no mean order, whose word carried much weight. At the Bangalore Manœuvres the Tactical Telegraphs, of which he made a special study, formed, under him, a marked feature; while in November, 1905, he took a Telegraph Section to the Rawal-Pindi Manœuvres, where his work was such as to receive universal approbation.

In the realm of sport and play it need only be mentioned that Bushell was a fine all-round sportsman, a keen polo player, a good cricketer, a brilliant racquet player, a tower of strength in our hockey team, and a good shikari.

Socially he was beloved by all who knew him, and his untimely death cast a gloom not only over the Corps, but over the whole station, which turned out "en masse" to attend his funeral, while letters of condolence arrived from all parts of India.

The Native Officers of the Corps asked, of their own accord, to be allowed to wear mourning for him, a small but significant sign of the respectful love which the Native ranks bore "Bushell doray." Had he lived there can be no doubt that his splendid qualities would have ensured him a brilliant career in the Service.

F. J. ANDERSON.
E. K. MOLESWORTH.

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THE REV. J. J. CURLING, M.A., LATE LIEUT., R.E.

THERE has recently passed from amongst us an old R.E., who in his younger days was liked by his contemporaries, and in his after life was esteemed and honoured by everyone who knew him, and why? Because, being a man of means he unselfishly devoted not only those means, but also his life, to promote the best interests of his fellow men. He had an unobtrusive, gentle, and charming manner, and no one who came in contact with him for a moment doubted the sincerity and genuineness of his motives and character; but behind the gentleness of manner there was a strong fixity of purpose, and plenty of energy to carry his purpose to useful maturity. The most casual observer could not fail to see that "Self" never entered his head. He had set himself a noble task, and his whole mind and energies were devoted to carrying that task to a successful issue. Such an unselfish and admirable character deserves notice in the Corps Journal. The record of a fine character insensibly produces a beneficial effect and tends to raise the tone of mind of those who read it, who begin to think, "Well, after all, there is some good in this wicked world."

Curling was educated at Harrow, and entered the Royal Military Academy at Woolwich direct from that school. There he did well, obtained his commission in the Royal Engineers, and received the "Sword of merit" on leaving in 1865. His contemporaries speak of him as rather reserved in character, taking little part in ordinary games except racquets at which he was a proficient, and never joining in the somewhat riotous amusements which were not uncommon at the Academy in those days, but bright and cheery and full of quiet energy.

His tastes were decidedly nautical, and when at Chatham he was generally one of the crew of the *Violet*, on board of which there was no better hand in an emergency. Sometimes his energy found vent in venturesome, not to say foolhardy, expeditions. As examples it may be mentioned that on one occasion, whilst quartered at Dover, he paddled and sailed across the Channel in a canoe—not as a sensational expedition, but at night—by himself, and unknown to anyone until he returned with his canoe in the steamer. On another occasion he started one evening to row in a light sculling skiff from Gravesend round by Sheerness to Chatham, and after meeting with some adventures, as was not surprising in the dark, reached his destination safely. When at Gravesend as Assistant Musketry Instructor, soon after leaving Chatham, he owned the *Lavrock*, a yawl, 72 tons. In a little "brochure" the late General Drake, R.E., always an amusing writer, speaks of the *Skylark* (*Lavrock*) as Curling's first love and the joy of his heart. Being an old yachtsman myself I can quite imagine that Drake was not far astray. The "brochure" is an amusing account of a trip in the *Skylark* across the Channel to Havre

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and back, in October, 1868. In that year Curling was elected a member of the Royal Yacht Squadron, and continued a member until his death.

In April, 1869, he went to Bermuda as A.D.C. to General Sir Fredrick Chapman, R.E., the Governor; this suited him well, as he had there every opportunity of enjoying his favourite sport.

When at Bermuda he met the Bishop of Newfoundland and had much conversation with him as to the circumstances of his Diocese and his visitation voyages to distant places in it. After his return to England in 1870, when still holding the appointment of A.D.C. to Sir Fredrick Chapman, who had become Inspector General of Fortifications, Curling heard of the wreck of the Bishop's "Church Ship" and promptly offered his yacht the *Lavrock* to replace her, a most generous gift, illustrating both his liberality and the tendency of his mind. The offer being accepted he had her thoroughly overhauled and, having obtained leave, navigated her across the Atlantic to Newfoundland, where he handed her over in 1872 as the new "Church Ship."

In 1873 he retired from the Corps, and took Holy Orders the same year, as he had then determined to devote himself to active missionary work in Newfoundland. It is impossible to look into the hidden springs of his mind which induced him so completely to change his career in life, but his resolution once formed was carried vigorously into effect. He went to Newfoundland, and worked hard as a missionary for nearly 20 years amongst the fishermen and others. Being a good seaman and fond of everything connected with the sea, he was singularly fitted for the work to which he had devoted himself. During this period he took his degree at Oxford, coming over from St. John's to keep the College terms.

About the year 1880 he was appointed Rural Dean of the Straits of Belle Isle and in that capacity had spiritual charge along some 600 miles of coast. To enable him to visit the far apart places in his District he designed and built *The Sapper*, a small schooner of about 57 tons Thames measurement, and in 1882 passed the necessary Board of Trade examination and obtained a "Master's Certificate."

Whilst at St. John's, Newfoundland, he married a daughter of Sir Bryan Robinson, Judge of the Supreme Court, by whom he had four children, three sons and a daughter.

In 1892 he found it desirable to give up his work in Newfoundland and to return to England for the education and placing of his sons. As there was no longer need for *The Sapper* in Newfoundland after his departure, he sailed her home across the Atlantic, meeting some heavy weather on the voyage; and soon after his arrival he gave her to the St. Andrew's Waterside Church Mission.

He took up his residence at Hamble, near the entrance to Southampton Water, where he had purchased a house. The living of

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Hamble becoming vacant, he applied for it at the suggestion of some of his neighbours, was appointed, and remained there as Vicar for nine years.

In 1901 he retired from active work, and came for a short time to London before deciding where he would settle down. Returning from a ride one afternoon, early in 1902, his horse fell and threw him heavily, his head striking against the curbstone. He never really recovered from the injury he then sustained, but gradually failed, and passed away on the 18th of November last.

His three sons are all in the army, two in the Royal Artillery and one in the King's Royal Rifles.

He never ceased to take a deep interest in his old Corps, and when within reach he generally attended the Annual Corps Dinners for the purpose of meeting old comrades.—*Requiescat in pace.*

G. A. LEACH.

COLONEL ROBERT HAWTHORN, LATE R.E.

ROBERT HAWTHORN joined the Royal Military Academy at Woolwich on the 1st May, 1847, at the age of 14; and obtained his commission in the Royal Engineers on the 19th June, 1850, passing out at the head of his batch and receiving the 1st prizes for mathematics and fortification.

After the usual course of instruction at the School of Military Engineering at Chatham, followed by two years at Woolwich, he was ordered, in December, 1854, to Bermuda. Returning home in March, 1858, he served a year at Chatham and two years at Weymouth, where he married a daughter of Capt. Wm. Dow, Royal Navy, and thence proceeded to Gibraltar. In October, 1864, he came home again, and after nearly two years at Sheerness he once more went abroad, this time to Ceylon, where he remained until August, 1871.

His station on arriving home was Pembroke, and his five years there saw him promoted major (5. 7. 72) and lieut.-colonel (1. 4. 76). From November, 1876, to June, 1880, he was in command of the R.E. Companies at Portsmouth, where he interested himself greatly in the Sappers under him, becoming a total abstainer to help the temperance movement in the garrison.

In June, 1880, he embarked for South Africa. On the outbreak of the Boer war he was detailed to the Communications, and appointed Commandant at Pietermaritzburg, and it was not until after Majuba that he was able to go to the front.

Having become brevet colonel on 1st April, 1881, he returned home in July, 1884, and served for nearly a year at Woolwich. On 2nd July, 1885, he was promoted substantive colonel, and appointed

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Commanding Royal Engineer of the Thames District. Hawthorn was always devoted to the interests and well-being of the Sappers; and during his time at Chatham he took the greatest interest in the success of the R.E. Temperance Society, of which he was president.

In January, 1888, when the appointment of C.R.E. at Chatham was temporarily amalgamated with that of Commandant of the School of Military Engineering, he was sent as C.R.E. to Jersey. He completed his service there in July, 1890; and on 28th October of that year he was placed on the retired list after nearly 40½ years' service.

After his retirement Hawthorn settled in London. In the summer of 1899 he moved to Wimbledon, and early in the following year to Bath, returning to London again in the spring of 1903. In the winter of 1905–06 he went to Florence, where he died of pneumonia on the 18th December last.

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TRANSCRIPT.

THE POSITION OF THE 3RD MANCHURIAN ARMY AT MUKDEN.*

WHEN General Baron Kaulbars arrived to take over the command of the newly-formed 3rd Manchurian Army on the 16th December, 1904, he found the troops already on the ground. As the senior members of his staff had not arrived, various acting appointments were made, and among these the post of Inspector of Engineers to the 3rd Army fell to the writer of this article.

Composition of the 3rd Manchurian Army.

The 3rd Army consisted of the 17th Army Corps (General Baron Bilderling), the 6th Siberian Corps (General Soboden), at first the 1st Army Corps (General Meyendorf), and subsequently the 5th Siberian Corps (Lieut.-General Dembovski). The troops occupied the irregular line which they retained at the end of the unsuccessful autumn battles. Their positions were consequently not selected, but fell to them quite accidentally, and contained many essential defects, towards modifying the prejudicial influence of which engineering skill was called into use.

Description of the Position.

The 3rd Army occupied the centre of the Mukden position with the 1st Army on its east side and the 2nd Army on the west. Its front line was shaped like a bow, concave towards the south, the most northerly point being the works opposite the railway bridge near Linshinpu, which itself was in the hands of the Japanese. The river Shaho ran past the eastern part of the position; its upper waters, as far as the village of S. Wandikudyaza, were in the Russian territory; below this the Japanese held both banks as far as the railway bridge, beyond which the Russians held the north bank as far as Linshinpu, where the river turned south and passed entirely into Japanese territory.

The accompanying plan shows details of the position, with the fortified villages and the works constructed in the intervals between them.

5th Siberian Corps.

Starting from the west flank the 5th Siberian Corps held the front line from Kandzyatai to the Dalantun group. In this section the ground was practically level. As regards the defences it is noted that the intervals between the various works were not so completely obstructed by trenches and approaches as in other parts of the line. The second line of this section extended from Tuyp-pu to Sifantai (exclusive).

17th Army Corps.

The section of the 17th Army Corps extended from Dalantun to N. Wandikudyaza (exclusive). Here the ground continued practically

* *Précis* of an article by Colonel G. P. Chornik, Russian Engineers, in the May, 1906, number of the *Eenzhenernee Zhoornal.*

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level, but was commanded by high ground on the left bank of the river. In this section was included the village of Linshinpu, the northern edge of which, including a fort named after the Resurrection, was held by the Russians, the rest of the village being in the hands of the Japanese. Here also were some brick-kilns, from the cover of which a mountain battery enfiladed the lower reaches of the river. In the space between the hostile lines immediately east of the railway were two groves of trees, called the Aspen Grove and the Black or Fir Grove, of which the former frequently changed hands between the combatants but the latter was always in the possession of the Japanese. The second line of the 17th Army Corps extended from Sifantai (inclusive) to Guantun (exclusive).

6th Siberian Corps.

The front line of the 6th Siberian Corps extended from the villages N. and S. Wandikudyaza to Khousandachanza (exclusive). The ground near the river was much intersected by nullahs; and there was some higher ground to the south, which however was completely commanded by the hills named Kho-utkhai and Slyusarenki within the Japanese lines. This section included the Mandarin road and the important bridge-head at Sakhepu, consisting chiefly of the fortified temple enclosure, the rest of the village being demolished; this point gave support to a large system of trenches forming the salient angle of the line in this part. The second line extended from Guantun (inclusive) to Podavyaza.

1st Army Corps.

The front line of the 1st Army Corps extended from Khousandachanza to Liudzyatun. The ground was hilly, intersected with ravines, and included the Putiloff and Novgorod hills, which were commanded by the hills already mentioned in the Japanese lines. In this section there were rather too many redoubts, which was due to the extreme tactical importance attached to this part of the position.

Difficulties Encountered.

The Russians found considerable difficulty in defilading their works and approaches from the high ground held by the Japanese. It was also a great inconvenience that their works faced towards the south, as they not only had to fight with the sun in their eyes but their works were not easily concealed, while the Japanese works, being generally in shadow, were well hidden.

A difficulty, common to both antagonists, was that of making earthworks when the water-logged ground was frozen to a great depth. It was soon found that ordinary entrenching tools were useless, and that tasks averaged $\frac{1}{4}$ to $\frac{1}{2}$ cub. ft. per hour. The Japanese tried lighting fires to thaw the ground; but the Russians soon decided to use explosives, and the question arose as to which kind of explosive was the most convenient. Gunpowder required too bulky a charge; pyroxiline was not procurable in sufficient quantities; dynamite was available, but was unsafe in its frozen state; and finally the choice fell upon rak a rock, an American explosive consisting of two parts, a butter and an absorbent, which are mixed just before fixing the charge. This proved satisfactory, but was somewhat less powerful than pyroxiline.

The Sapper boring tools were rejected in favour of machine drills, with which 3 or 4 men could make a hole 3 ft. to $3\frac{1}{2}$ ft. deep in 3 to 5 minutes. In such a hole a $\frac{3}{4}$ lb. charge of rakarock would produce a kamouflet,

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breaking up the ground into fragments which could be got out with crowbars or entrenching tools or even with the hands. In this way the rate of progress of the work was much increased and there was also a great reduction in the number of tools broken on the works.

The Fortifications.

As to the fortifications themselves, where possible there was little or no parapet, and where not formed like a glacis the parapets were made not less than 12 ft. in thickness. In trenches not exposed to enfilade fire, as a protection against splinters, traverses were placed not further apart than 25 paces; and portions of the trenches skirting parapets and traverses were covered with light splinter-proof shelters as a protection against shrapnel. The frozen earth allowed the sides of excavations to be vertical.

Field casemates were placed in small trenches somewhat in rear of the firing line and were covered with beams taken from the Chinese tombs. These beams were 14 in. to 28 in. thick, and by themselves or with only a thin layer of earth gave sufficient protection against anything but direct hits from large shells; owing to the difficulty of excavating, the risk of such shells was generally taken. In addition to these casemates the troops excavated for themselves in the trenches niches for individual men, sometimes under the parapet, but more often under the rear side of the trench; the former was forbidden, more as a matter of principle than from any real danger of weakening the parapets in the frozen ground.

Communication Trenches.

In the various works communication trenches were made to connect the faces with the gorges; these trenches were given a breadth of 1 pace, or, if required for machine guns, of 3 paces. It was intended to make them from 6 ft. to 8 ft. deep; but time rarely permitted them to be completed, and it remained with the enthusiasm of the commander of each redoubt whether or no the communications were improved after it was occupied by its garrison.

In the same way the communications between these works and the ground in rear were seldom at first brought up to their full profile, and improvements were carried on gradually when men could be spared from more pressing work. In the section of the 6th Siberian Corps, which had been previously occupied by the 10th Army Corps, the latter troops had begun a great number of communication trenches, some of which remained in places not more than $4\frac{1}{2}$ ft. deep, while others were so narrow that not only was it inconvenient to carry wounded along them but even individual men found it difficult to pass one another. Many of these approaches remained unfinished to the end; and though a great deal of labour was spent on them, the writer acknowledges that not a little of it was useless.

Observation Posts.

In every work there was an observation post, but opinions differed as to the best place to put it. Some posts were placed in the salients of the firing line, where they could find cover in the angle of a traverse; while others were placed in the rear parts of the works, in specially constructed casemates raised above the level of the firing line.

Machine Gun Emplacements

Machine gun emplacements were constructed in the various works, generally in salient angles, the guns being kept in blindages until they were wanted.

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Rifle Trenches. In profile the trenches were kept as low as was permitted by the time available, the underground water, and especially the facilities for firing. They were made 1 pace wide at the bottom and, if possible, not less than 6 ft. below the ground level, the sides being very steep and in places vertical.

Loopholes. The works and trenches were constructed without any form of loopholes, but the troops occupying them made these for themselves with sandbags or any other available material. Sometimes in salient angles the engineers, by special request, made loopholes in the form of continuous slots with light head cover; and when carefully masked these were very effective.

Exterior Ditches. All the works made before the frosts began were given exterior ditches, either triangular or rectangular in section and in depth approximating to 9 ft. In those of four-sided section it was usual to put wire entanglements, but the writer preferred to put these obstacles by themselves some distance to the front.

Obstacles. For obstacles it was at first the custom to make deep military pits and shallow pits with stakes, the former strengthened with wire entanglements; but after the beginning of the frosts the only obstacles used were wire entanglements and *chevaux-de-frise* or abattis, both of the latter being entangled with wire.

The entanglements were made not less than 14 ft. in breadth. There was great difficulty in driving the stakes into the frozen ground, and considerable use was made of a Chinese implement, probably a sledge pole, which had a sharp point and could be driven into the ground or frozen into holes in the ice. These were also largely used for anchoring *chevaux-de-frise*.

Chevaux-de-frise. Various forms of *chevaux-de-frise* were used as substitutes for the stakes of wire entanglements, either when the latter had to be constructed under fire or on ice or frozen ground. Two kinds are described, (1) one consisting of a series of equal-armed wooden crosses joined to a common shaft, and (2) the other of three stakes of equal length joined at their centres at right angles to one another, with all the ends sharpened. They were lashed together with wire, anchored down, and then entangled with wire.

Other Wire Obstacles. In places tree-trunks, shrubs, and bushes were entangled with barbed wire. Fences were also made of barbed wire, but these were used only as temporary obstacles during the construction of entanglements in rear of them, after which they were removed. Empty tins, bells, etc., were occasionally hung on these fences, but this was less popular with the Russians than with the Japanese.

Military Pits. In the snowless wind storms of the Manchurian winter it was found that military pits soon became silted up with sand and ice, and the task of clearing them at night was not a popular one with the troops. If the pits were reinforced with wire entanglements this operation became more difficult. The obstacle formed of pits and wire was necessarily high and consequently difficult to conceal.

Abattis. Abattis were not much employed. They were used as obstacles on the ice when material suitable for making *chevaux-de-frise* was not available.

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They ran the risk of being stolen for firewood, and for this reason it was advisable to entangle them well with barbed wire.

Fougasses.

The writer regrets that the number of fougasses was limited by the small number of exploders to be found in the equipments of the Sapper companies. Shortly after the setting-in of winter one fougasse, exploded prematurely during a false alarm, revealed the fact that the charges at a depth of 6 ft. were too weak in the frozen ground; consequently all the others had to be recalculated and increased.

General Notes on Obstacles.

The Mukden position showed a great tendency towards the excessive use of obstacles, leaving little room for *active* defence.

The distance of obstacles from works did not exceed from 50 to 100 paces, and in places in close proximity to the enemy they were much nearer. At Linshinpu for instance they were only a few paces away.

The obstacles suffered little from the enemy's fire, but they were all inspected each night by Sappers and, where necessary, repaired. But they often suffered severely from the Russian fire, especially by night, and when there had been much night firing a second inspection was always necessary.

Great care was taken in masking all obstacles; and high standing ones were placed in shallow broad trenches with glacis in front, which were in their turn carefully disguised.

Field Artillery.

The quick-firing artillery with the 3rd Manchurian Army numbered 31 eight-gun batteries, or 248 guns. The following are the numbers of these batteries in the accompanying plan of the position:—13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 44, 45, 47, 48, 49, 52, 53, 54. There were also 5 eight-gun batteries (or 40 guns) of ordinary field guns (Nos. 12, 18, 46, 50 and 51), and one battery (No. 19) of 8 heavy field guns. In all, 296 field guns.*

The quick-firing batteries were placed in special trenches, and used indirect fire. Where possible the guns were placed at intervals of 25 paces, and in the intervals there were trenches for the detachments, niches for ammunition, and field casemates.

These batteries were at first all placed in the second line of defence, but later they were moved to between 1,800 and 2,800 yards distance from the enemy's works.

Owing to the nearly continuous lines of the front trenches, the guns were almost always firing over the heads of their own infantry; and consequently, when opposing an attack, they had to discontinue their fire when the enemy arrived within 800 paces of the Russian works. As in some places the hostile lines were not further than this distance apart (*e.g.* at Linshinpu and Vujhanin), some of these most important points were thus entirely bereft of artillery support. The writer recommends the Japanese method of keeping a few guns concealed in pits in the trenches themselves, from which they can be brought into action at the moment of necessity and returned under cover when no longer required.

It was a serious defect that the quick-firing guns were not provided

* Batteries Nos. 1, 2, 3, 7, 8, 9, 10, and V were composed of 6″ guns; Nos. 4, 5, 6, 11, A, and B, of 4·2 m.m. guns; Nos. 26, 27, 28, 29, 30, 39 55, 56, 57, of 6″ howitzers. Nos. 58 and 59 were intended for 8″ howitzers. See below and also Table on Map.

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with common shell, as their shrapnel was powerless against troops taking shelter in villages or in any form of cover. For this reason the ordinary field guns, which fired common shell, were allotted to the army; but they were not adapted for indirect laying and were consequently difficult to conceal. The writer considers that the Japanese had a great advantage over the Russians in having shimoze shells for their field guns; although these shells did little harm in the frozen ground and could not be called satisfactory, they nevertheless had a strong moral effect and were considerably better than shrapnel when employed against troops under cover.

Siege Artillery.

In view of the strength of the Japanese defences, and also partly to create a diversion in favour of General Grippenburg's attack with the right wing, it was subsequently decided to introduce siege artillery into the lines. But though many of the batteries were ready armed when this attack took place, towards the end of January, they were not allowed to open fire; and after the defeat some of the guns were transferred to the 2nd Army for use at Sandepu and elsewhere.

The following table gives the original scheme for the distribution of the siege-train in Manchuria; it was afterwards considerably altered :—

Description of Gun.	Kharbin.	Allotted to Army.			Total.
		1st.	2nd.	3rd.	
6″ steel guns of 4,366 lbs	6	8	—	40	54
4·2 m.m. guns	—	8	—	20	28
8″ howitzers	16	—	—	—	16
6″ field howitzers not horsed	—	10	—	30	40
6″ field howitzers horsed	—	—	8	—	8
Light field guns not horsed	—	8	—	32	40
Rocket tubes	26	—	—	—	26
15-pr. S.B. mortars	20	—	—	—	20
Machine guns	—	—	8	—	8

The siege guns eventually allotted to the 3rd Army were as follows :—

6″ *guns of* 4,366 *lbs.*, 34. (Batteries Nos. 1, 2, and 3 had 5 guns each; No. 9, 6 guns; Nos. 7, 8, and 10, 4 guns each, and V 1 gun).

4·2 *m.m. guns*, 20. (Batteries Nos. 4 and 5 had 5 guns each; Nos. 6 and 11, 4 guns each, and A and B 1 each).

6″ *field howitzers* (*horsed*), 24. (Batteries 26, 30, 39, and 55 each had 6 of these howitzers).

6″ *field howitzers* (*not horsed*), 30. (Batteries 27, 28, 29, 56, and 57 each had 6 of these howitzers).

8″ *howitzers*, 8. (Batteries 58 and 59 were each built for 4 of these howitzers, but were never armed).

Batteries Nos. 9 and 30 were subsequently disarmed and their guns sent to the 2nd Army.

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Further details of these batteries are given in the accompanying table. The most effective gun batteries were Nos. 5, 6, and 7 and the most effective howitzer batteries Nos. 27 and 39.

The author criticises the tendency to place the siege guns at too great a distance from the enemy, thereby losing the full advantage of their ballistic qualities and resulting in an unproductive expenditure of ammunition.

All the siege guns used indirect fire and were thoroughly concealed. The guns were placed at intervals of 21 yards, and were sunk in pits, except where the dampness of the subsoil did not allow of this. In the traverses were casemates for the garrisons, and in their rear slopes niches for ammunition. On one flank there was generally a strongly roofed reserve magazine, and on the other flank a casemate for officers. The melinite shells were stored separate from the other shells.

Japanese 11" Howitzers.

The Japanese brought up some 11" howitzers from Port Arthur and mounted them opposite this position. The Russians could not understand the object of this, but assumed that the enemy trusted in the demoralising effect of the huge shells; the Russian troops, however, soon got used to them, when they found that they did comparatively little damage.

General Criticism of the Position.

In studying the defences at Mukden, the fact must not be lost sight of that the troops did not select their defensive lines, but entrenched themselves where they stood at the end of the October battles. Much unnecessary loss would have been saved, and the troops would have been less harassed, if they had been drawn somewhat back to enable them to entrench themselves under normal conditions.

The writer's idea of a strongly entrenched position consists of a line of powerful redoubts or similar works, reinforced by obstacles and provided with wing trenches or "whiskers" (which increase the development of rifle fire and afford cover to the garrisons during a bombardment), with no connection between the works except a strong bond of fire.

Owing to the rapid fire of modern artillery, it is better to keep only a few men in the firing line, and to hold the reserves under cover, ready when required to occupy all works at the rate of one man to every two or three paces of the firing line. Machine guns should also be kept at hand under cover, ready to be brought into action at a moment's notice; these are useful in the works themselves, but are better placed in the intervals, drawn somewhat back.

Parapets.

There are two points to be considered with reference to the custom of reducing the parapets of works and trenches, (i.) the difficulty of disposing of the earth, and (ii.) the risk of insufficiently commanding the ground in front; against such skilful individual skirmishers as the Japanese this last was a serious consideration.

Villages.

In defending a village the trenches were thrown out to the front, enabling the troops to remain in them safely during the bombardment of the village. Villages gave good cover against shrapnel; against shimose and other high-explosive shell, the keeps should not be in temple yards or suchlike enclosures, but must be specially constructed earthworks.

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Screens. For concealing works rough earthen screens were extraordinarily successful. In one instance the ruins of a brick house, which lay behind a howitzer battery and were covered with a little earth as a protection against splinters, were successful in drawing the enemy's fire; and in another case a deserted village which matched in colour another lying in front of it, behind which was placed a battery of quick-firing guns, also became an accidental screen. The Japanese frequently screened their batteries with smoke, the prevailing south wind favouring them in this. They also made frequent use of flashes and dummy guns.

In masking works with millet stalks care was taken to continue the existing rows of the plants over the earthworks, and this was also done with the furrows of ploughed fields. The top earth was also put aside to be spread over the lighter yellow soil of the lower excavations.

Batteries. In selecting sites of batteries care was taken to enable fire to be brought on as large a number of targets as possible, allowing the guns to be concentrated on each target in turn. The large supply of observation posts, connected by telephone with the batteries, aided considerably the good shooting of the artillery.

Japanese Obstacles. As far as could be ascertained the Japanese used the following obstacles in their defences:—Abattis, both of the ordinary kind and strengthened with wire and cable; deep military pits, usually combined with wire entanglements; fougasses; *chevaux-de-frise* made like the Russian ones; on a few occasions palisades; and finally wire entanglements. The latter were made very high in the middle, the centre line of stakes standing about 6 ft. out of the ground. They generally had two cables run through each entanglement, one about 18 in. above the ground in the rear part of the obstacle, and the other carried in an irregular line along the high central stakes.

Shields. Many proposals were made of various kinds of shields for covering the approach of individual men towards the enemy's works; these were made up by the Sappers in Mukden and sent to the various sections for trial, but none were reported on favourably. One of these so-called mantlets is described as follows:—A drum was made of planks, in diameter about 4½ ft., and of such length that two men could take cover and shoot from behind it; inside, there were radial partitions, meeting at the wooden axis, made of planks covered with iron, the partitions being so placed that as the drum was rolled along some of them would always be in a position to stop a bullet. When tried these mantlets proved clumsy and inconvenient.

Devices for Crossing over Obstacles. A contrivance for crossing entanglements is also described,—a huge mat of millet stalks, rolled up and bound to a sledge, the shafts of which were to be run up to the obstacle and the mat then unwound over it to form a passage for climbing over: this device was found to be extraordinarily bulky, heavy, and clumsy.

Small carpets made by sewing Chinese mats together in two or three thicknesses were more popular with the troops; in use they were placed on light poles thrown on to the entanglement. Ladders of split bamboo were also popular. But the best methods of getting through entanglements were by means of bags filled with hay, straw, tow, etc.; or by

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cutting the wires with pyroxiline charges on poles or with cutting pliers.

In each section reconnoitring parties were constantly employed in studying the enemy's works, and from their reports charts were drawn up and corrected daily as fresh information arrived. Reconnaissance.

For verifying these charts, during January, 1905, a company of the 1st E. Siberian Balloon Battalion was temporarily attached to the 3rd Army. They worked constantly between the 10th January and 9th February with a captive balloon from the following villages :—Pendianza ($3\frac{1}{2}$ miles from the nearest Japanese batteries), Lanshanpu ($3\frac{1}{2}$ miles), Uenchenpu ($3\frac{1}{3}$ miles), Tacsun (4 miles), and Tuyp-pu ($4\frac{1}{2}$ miles). The Japanese fire did not allow them nearer than this. Balloons.

The weather was bright and sunny but there was almost always a slight mist, which concealed distant objects, and a strong breeze, which made the use of telescopes and field-glasses, necessary for observing against the sun, very difficult; and it was only on one or two clear days that any useful information was obtained. The company returned to Mukden when it was most wanted, having used up all the material for making gas.

The balloon envelopes proved very unsatisfactory in the extreme cold, possibly through the lacquer with which they were impregnated becoming brittle, and frequent failures occurred.

The writer has not a high opinion of the utility of balloons, and considers the idea of taking photographs or observing artillery fire from them as utopian. He is more in favour of kites, both those fitted with photographic apparatus, without an observer, and those carrying an observer. At his instigation a specialist in kites was telegraphed for, and set to work; but he had not got beyond the experimental stage, with (it was said) good results, when the battle of Tsu-Shima and proposals of peace caused his work to be stopped by command. Kites.

F. E. G. SKEY.

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REVIEWS.

THE RUSSO-JAPANESE WAR.

Compiled by the GENERAL STAFF, WAR OFFICE. PART I.—(1s. 6d. Wyman).

IT is understood that this work will be completed in eight parts. The first part, 75 pages and appendices, deals with the events leading to the war, the strength of the belligerents, the theatre of war, and the operations up to and including the battle of the Ya-lu. It contains five maps, three of which illustrate this battle.

The work does not claim to be complete and accurate in every respect; but all available information, with the exception of such matter as it has been considered necessary to withhold, has been utilized. Criticism has been excluded.

A very clear account of the operations is given; and as the book is likely to be the only authoritative one in English for some years to come, it is recommended to the notice of officers, especially those who have promotion examinations before them.

'E.'

THE RUSSO-JAPANESE WAR ON LAND.

By CAPT. F. R. SEDGWICK.—(3s. 6d. Forster Groome & Co.).

As this is, at present, the only book in English which attempts to give a complete account of the operations on land, it is much to be regretted that the author has not based it on the good authorities now available :—the Austrian account published by Seidel, the articles in the *Russki Invalid*, and the *Einzelschriften* of the German General Staff, etc. Amongst the errors in the first few pages are the statements that the whole of General Kuroki's army was landed at Chemulpo and occupied Seoul (only 1 division was disembarked there and only a small portion of this went to Seoul); that the Russian position at the battle of the Ya-lu "was cut in half by the Aiho River" (it was behind the Ai River and not divided by it); and that 3 divisions under General Oku and 2 divisions under General Nogi commenced disembarking, the former "opposite Elliot Island" (*sic*) and the latter "about Pitzevo," on the 5th May (it was General Oku who landed near Pi-tzu-wo, and the 9th and 11th

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Divisions, given as Nogi's army, did not commence landing till the end of July and May respectively).

The author's difficulties with the spelling of place names are perhaps excusable, but there seems no reason he should spell Manchuria as Mandchurija, Ta-shih-chiao as Daschitza, Ussuri as Ursari, etc., etc.

'E.'

ACHTZEHN MONATE MIT RUSSLANDS HEEREN IN DER MANDSCHUREI. VOL. I.

By MAJOR FREIHERR VON TETTAU.—(8s. 6d. Mittler, Berlin).

This is a work that should be read by every officer. The author, a well-known authority and writer on the Russian Army, was one of the German attachés with the Russian forces during 18 months of the war in Manchuria. Proficient in the language, and having made the acquaintance of many Russian officers during visits to Russia, he enjoyed exceptional facilities for learning the events of the campaign as they were taking place; and his training on the Great General Staff enabled him to take full advantage of the opportunities thus afforded.

His first volume, which has just been published, contains the story of the war up to the retreat from Liao-yang. As Freiherr von Tettau was attached first to Count Keller's detachment and afterwards to the X. Army Corps, which opposed the advance of General Kuroki, he relates the same events as Lieut.-General Sir Ian Hamilton did in *A Staff Officer's Scrapbook*, but from the other side.

In his preface the author says :—"I cannot report any successes of the Army whose comradeship I enjoyed for a year and a-half. The guest who chatters unpleasant things outside the house in which he has been received with hospitality may be counted as ungrateful. And yet the depicting of the events of a war is of value only when the author speaks his mind openly and freely. Only in this way will those be served who wish to draw lessons from the war. Every Army has had to go through times of misfortune like the Russian in this campaign. When, however, the causes of the ill success are freely recognised, and efforts made to remove them, then the pendulum will quickly swing the other way."

Writing in an objective spirit, free from personalities, the author has given a very vivid picture of the Russian Army in war and a most excellent study of the methods of its commanders. Since he was often initiated into the thoughts of the generals with whom he served, and was given copies of orders (which are printed at length in the appendices), his account will probably be the most complete that we shall have from the Russian side for many years to come.

One thought seems to have had the mastery in the mind of every Russian leader, and is accountable for many a lamentable failure; this

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was "position." The word appears on nearly every page. Not content with selecting a "main position" there were also always "advanced positions," "rear positions," and "intermediate positions" to be considered. The first officer the author met was going not "to the front" but to the "position" of his regiment. When it was discovered that the 1st Japanese Army was endeavouring to cross the Tai-tzu Ho at the battle of Liao-yang, the 35th Division, instead of advancing and attacking the enemy during the crossing, took up a "defensive position." One Army Corps Commander, when the Japanese took the offensive after a delay had prevented one of his own divisions from advancing, remarked to Major von Tettau, "How lucky Vassiliev had not marched off; otherwise he would have run into the Japanese when we had no 'position.'"

Owing to the Japanese having drawn first blood, at the battle of the Ya-lu, there was terrible confusion in the Russian Army; and new units, as they arrived, were rushed off to fill a gap anywhere, to the dislocation of all the higher commands. The same thing occurred in the early part of our war in South Africa, and is generally the case with an army unready for war.

When the X. Army Corps arrived at Liao-yang, one infantry brigade, with artillery, was at once pushed into the mountains to support Count Keller; another brigade with artillery was sent up the Tai-tzu Ho; the third brigade was sent south to General Stakelberg; the fourth brigade with 6 batteries was retained at Liao-yang at the disposal of the Commander-in-Chief; the rifle regiment was sent to Count Keller; and a cavalry regiment, with the mountain battery, was attached to General Rennenkampf's Cavalry Division. This left 2 squadrons of a second cavalry regiment; one of these was sent to protect the Army Pontoon Park, and half of the other was detailed as escort to the Grand Duke Boris, leaving the Army Corps Commander with half a squadron. "Apart from this he controlled not a single man." "There was not at the time (8th July, 1903) one higher Russian leader who had the whole of the troops belonging to him under his command."

The specimens of "operation orders" which are given show that the higher commanders constantly interfered in the provinces of their subordinates, legislated with regard to the smallest details, and often prescribed courses in the event of contingencies. General Count Keller appears to have been killed because he considered his place in action as commander of a detachment was in front, with his orderly bearing his flag close behind him.

General Kuropatkin, when present during fighting, does not seem to have assumed command himself, but to have told off a subordinate not necessarily the senior to take charge; with the result that, on the 2nd September, 1903, at Liao-yang, opposite the 1st Japanese Army, a junior, thus temporarily in command, ordered a senior general to carry out a certain attack with his troops, with the remark—"But for the execution of this task I place myself under your excellency."

The volume contains 400 pages, 8 excellent maps, and numerous photographs.

'E.'

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FIELD FORTIFICATION AND MODERN ARMAMENTS.

By LT.-COL. DU GÉNIE CLERGERIE.

The first part of this book is devoted to the fire effect of modern field artillery. The angle of descent of the projectile, the cone of dispersion of the fragments, and the maximum angle of impact that will cause a shell to ricochet are taken as the data from which various types of fire trench are deduced. None of these present any novel or interesting features.

The trenches are not provided with either head or over-head cover, and the writer admits that the troops using them could not show their heads above the parapet in the face of artillery fire. He intends that the garrison of the trenches should crouch under cover until the hostile artillery has prolonged its range to permit the attacking infantry to advance to the assault. The possibility of the trenches being enfiladed by the enemy's artillery does not appear to have been considered.

It is stated that the rear cutting edge of a trench is very conspicuous to an observer in a balloon, and to obviate this it is suggested that the parapet should be made high enough to cover it from view.

The second part of the book, which deals with obstacles, consists of two pages only.

In the third part the author discusses the tactical employment of field fortifications. He considers that the infantry of the defence should not open fire until the enemy are within 400 yards of the trenches. By reserving their fire they will expose themselves as little as possible to the hostile artillery, and will probably be able to surprise and crush the enemy's infantry by an overwhelming fire at short range. A field of fire of from 400 to 250 yards in length should therefore be ample. If the defence works have a total length of crest line equal to from a third to a half of the front of the position, the attacking infantry should not be able to establish a superiority of fire. The possibility of enfilade fire is not apparently taken into consideration. The writer evidently intends that the defence works should be placed in groups forming *points d'appui* along the front, but he does not actually say this.

Several pages are devoted to the siting of works, but no very definite conclusions are arrived at. The dominant factor in the author's mind is evidently the artillery fire of the attacking force, and to escape this he is in favour of placing the main line of defence on the rear crest of a hill. In order to prevent the enemy from massing on the lower slopes of the hill, he proposes to place some well-concealed advanced works on the front crest. The idea is that the enemy should exhaust their troops and ammunition in capturing the advanced works, only to find themselves confronted at short range by a new and intact position on which they cannot bring artillery fire to bear.* The object to be kept in view in arranging defence works is to bring the heaviest possible combined

* This system finds much favour with modern French writers. It has already been fully described in this *Journal* (September, 1906) in Capt. Swinton's "Defence of a Position upon Open Ground."—J.E.E.C.

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infantry and artillery fire to bear on the enemy's infantry at the moment when they advance to the assault.

In fortifying a locality the defences must be made to suit the *rôle* that the garrison are intended to play. Particular attention must be paid to communications, especially to those that will be used for counter-attacks. The organization of communications is the special *rôle* of the Sappers. Lines of communication should not pass through villages, as they are very liable to be blocked by an outbreak of fire, or by fallen houses, etc. If a village is to be held, positions should be taken up on each flank, the village itself remaining unoccupied, and serving merely as an obstacle to the enemy's advance and as a screen to cover the reserves. In clearing the field of fire trees should be left standing unless they can be removed altogether; the lower branches should be cut off. Haystacks should be removed, and must not be set on fire, as they burn very slowly and make an enormous amount of smoke.

The last section of the book professes to deal with the employment of fortification during an engagement, but it is chiefly devoted to the tactics that should be adopted by a force acting on the defensive. It is suggested that the cavalry screen should be reinforced by strong detachments of infantry and artillery, which would occupy a series of defensive positions in front of the true position of the main body. These advanced detachments would fight a number of rear-guard actions, until they were finally driven back on the main position. The author believes that by this method the attackers might be subjected to heavy losses before coming in contact with the defenders' main body.

In conclusion he insists on the necessity for providing every soldier with a portable entrenching tool.

J. E. E. CRASTER.

MITTEILUNGEN DES INGENIEUR-KOMITEES.

PART 43.

This important publication of the German Engineer Committee is so closely packed with information that a summary of it would practically be a translation. As there is nothing of the kind like it in English it is much to be hoped that a translation will be undertaken.

It consists of 170 royal octavo pages, and is entirely devoted to a survey of recent literature on the subject of fortresses, fortress warfare, and field engineering.

The preface makes its object clear:—"The study of technical literature undoubtedly forms a material means to the scientific, and indirectly to the practical, improvement (*Weiterbildung*) of our officers. Unfortunately their time is so fully taken up by their onerous duties that often they are unable to keep close touch of it. The Engineer Committee intends therefore to issue compilations, which will at least make the readers

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generally acquainted with the most important new literature on fortress and field engineer matters, will incite them to study some special question, and indicate to them the best sources for theoretical and practical information."

The work is divided into 5 sections, with two appendices :—

(1). Land Defences and Fortresses.
(2). Permanent Fortification.
(3). Semi-permanent and Field Fortification and Engineer Material.
(4). Coast Defence.
(5). Fortress Warfare. Attack and Defence of Fortified Positions and River Lines.

Appendix 1. Literature of the Russo-Japanese War.
„ 2. Organization of Engineer Troops.

Each of the sections is divided into a number of sub-sections; thus No. 3 Section contains :—

General.
Semi-permanent Fortification. Definition and purpose.
„ Materials and general organization.
„ Details.
Field Fortification. Value, purpose and materials.
„ General organization.
„ Details.
Passage of rivers.
Explosives and mine warfare.
Railways, balloons, telegraphs, etc.
Landings.
Fortress warfare.
Semi-permanent and Field Fortification abroad :—
General.
France.
England.
Italy.
Austro-Hungary.
Roumania.
Russia.
Switzerland.
Japan.
U.S.A.
Semi-permanent and Field Fortification in military history.

A translation of the sub-section dealing with "Explosives and Mine Warfare" is given below and will serve to show the nature of the book :—

"Electrical mine firing is exhaustively discussed by Stavenhagen in the *M.G.A.E.*,* 1905.

* *Mitteilungen über Gegenstände des Artillerie-und Geniewesens.*

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"In the 'Attack of Fortresses' (*Jahrbücher für Armee und Marine*, 1898) Frobenius thinks it probable that in fortress warfare a number of the defensive arrangements—*e.g.* the iron fencing on the counterscarp and counterscarp galleries, etc.—can only be destroyed by mining, and deduces therefrom the necessity for a miner corps. In 'Retrospect of the historical development of Mine Warfare' (*M.G.A.E.*, 1899) Stavenhagen comes to the same conclusion, and demands the utilization of the present wonderful condition of technical material and machinery for perfecting mining apparatus. He draws attention *inter alia* to the rapid gallery driving proposed by the Belgian engineer officer Gillet, which in its latest form is described in 'L'Art Militaire à l'exposition universelle de Liége en 1905: Regiment du Génie' (*Revue de l'Armée Belge*, 1905).

"The essays 'Construction rapide des Mines' and addenda ('Recueil des travaux techniques des officiers du génie de l'armée Belge, 1897, 1900, and 1902') are instructive as regards the development of Gillet's system.

"In connection with Stavenhagen's 'Retrospect' mentioned above, Kutzlnigg (*M.G.A.E.*, 1899) discusses in detail the views of various military writers on mine warfare of the future, and various methods of driving galleries.

"In 'Mine Warfare' (*Kriegstechnische Zeitschrift*, 1902) Scharr considers this method of attack and defence with reference to the views expressed by Brialmont in 'Organisation et Composition des Troupes du Génie et de l'État Major de cette Arme.'

"The question of the most suitable section for galleries is, *inter alia*, discussed in 'Galleries for shelters and depôts' by Nerad (*M.G.A.E.*, 1900), in 'Fougasses in field and fortress warfare' (*Streffleur*, 1905, but extracted from the *Russki Invalid* and based on the experiences of Port Arthur), and in 'A new Mine System' by Op Ten Noort (*Kriegstechnische Zeitschrift*, 1906).

"Finally must be quoted 'Saragosse, Sébastopol, Paris, et Port Arthur' (*Internationale Revue*, 1905; *Supplement* 72), in which von Boguslawski *inter alia* refers to the importance of mining in fortress warfare, and 'Subterranean warfare' (*Schweizerische Zeitschrift für Artillerie und Genie*, 1905) by Stavenhagen, in which the necessity of still practising mine warfare is insisted on.

"Submarine mining is dealt with in Section 4."

It will be of interest to readers of the *R.E. Journal* that in Appendix 2, "Organization of Engineer Troops," reference is made to the articles on "Royal Engineer Duties in the German Army" by Major Edmonds, R.E. (*R.E. Professional Papers*, 1900), and "The Engineers of the German Army" by Colonel Ferrier (*R.E. Journal*, 1906); as they are recommended to German officers by a German official publication the articles may be taken as substantially correct.

There is a notice that "the Engineer Committee is preparing a work on Engineer matters in the Russo-Japanese War of 1904–05."

'E.'

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ENGLAND AND HER ARMY.

By H. V. BASEDOW, Lt.-Col. on the Staff of the 4th West Prussian Infantry Regiment, No. 140.—(Supplement of the *Militär Wochenblatt*).

A journey to England, says the writer of this lucid, and for the German reader, most illuminating brochure on the British Army, enabled him to study our system after a manner impossible for the ordinary home-abiding soldier of the Fatherland.

In well-nigh his first sentence we are glad to read an intentional friendliness towards us in the statement that, in spite of the much-advertised *Invasion of 1910*, by an English author, and of other essays by German writers dealing with the practicability of a descent upon our shores, the *average* German officer is more concerned with the progress and development of the military forces to east and west of him, than with the 'wild-cat' schemes of foreign and other "Jingoes" to steal a march upon the fleets and armies of Britain. And whereas we are not invited to criticise, but rather to summarise the contents of the pamphlet before us, we will accept the gallant author's critiques in the spirit in which he enters upon his task.

The author shows, on the strength of the preamble to the Army Act, that we *still* stand in awe of the shadow of Oliver Cromwell and the dangers of a "standing army," while up to the time of the campaign in the Crimea our military forces were nearer akin to an Imperial Police Force than a striking force modelled on up-to-date lines; and further that the Cardwell school of thought, of whom is Lord Wolseley, produced to a very great measure the army which fought in the South African war. *We* should perhaps read into the author's statement, though he does not connote the fact, that the logic, which sends half our army to serve beyond the seas in India and the Colonies, and trusts to a moiety and to the Fleet to protect our shores, is perhaps justified by the marvellous adaptability of the British soldier to his environment and the character of each fresh campaign, in respect of which he is perhaps only second to the Japanese warrior of the reformed army of our allies in the far east.

The system of two battalions, which, though serving under one county or other title, rarely meet, if ever, *as* battalions, is approved in normal times, as also the custom of exchanging horses when cavalry regiments take their turn on the roster for foreign service. The faults in the system are however summarised as follows, when the author records the modifications forced upon the War Office by the lessons of the last campaign.

(1). The Cardwell system made practically no allowance for expansion in time of great stress, in respect of the organisation of an adequate "striking force"; and thus (2) the reserves fell short of requirements; while (3) in the third place, the actual worth of the Militia and the Volunteers in warfare was left to be proved and evolved in the grim earnest of a campaign for which we were unprepared.

Next Mr. Brodrick's six Army Corps are mentioned and dismissed with the remark that, while one was a mere paper unit, the scheme came

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to an end with the transfer of Mr. Brodrick to the India Office, to be replaced by a system of seven supreme Commands, which have so far held together and may survive the Haldane administration and the (possible) introduction of the nationalised army of the future, a question with which, however, our author does not attempt to deal.

Nor does our author express a definite opinion on the proposal made, and now formulated, to provide a "striking force" or "general service force" of 90 battalions and other details with a service of 9 years with the colours and 3 in the reserve, and a "home service army" of 48 battalions, including the Guards, with a time limit of only 2 years with the colours and 6 in the reserve. For this is a question, which *should*, one might have thought, suggest some interesting remarks from a soldier, who is visibly stirred and impressed by the recruiting "posters," which mainly purport to fill the ranks of our voluntary army, from the point of view of the foreign critic.

The high wages which form the bait held out to the doubting recruit do not, according to our present authority, attract the very best of our manhood to the colours. Surely, however, the author is in fault in the statement that the social status of "Tommy Atkins" (the term is the author's, *not* ours) is to be appraised by the fact (?) that from many public places non-commissioned officers and soldiers in uniform are rigidly excluded? Moreover, stress is laid upon the easy life of the first few months in the army, the prohibition of long marches during the first half year's service, and the whilom all-night passes once served out to all and sundry with a view to popularising the service to the potential recruit. And then, last but *not least*, the very praiseworthy attempts of Lord Roberts and others to find and provide a trade for the soldier, when he merges again in civil life, as the State takes no cognisance of the soldier as a private citizen. But all these inducements, from a German point of view, are useless: the lack of recruits still continues and is like to continue.

The reserve therefore is insufficient, and is consequently dependent upon the Yeomanry, Militia, and Volunteers for a stiffening, which the writer in question obviously does not rate very highly. Is it not however a heresy to antedate the consolidation of the Militia forces so far back *only* as the middle of the 19th century on the alarm of a French landing in force upon our coasts? But this being a collation of facts, rather than a critique, we are bound to pass on, after noting this rather crude conversion of the old Constitutional Force, which was the germ and origin of the army of to-day, into a hypothetical body of "francs-tireurs" contemporary of the Volunteer forces, with which a more experienced soldier than our author might well have confused it.

It would however be tedious to follow the writer into details of the constitution and organisation of the Auxiliary Forces, which, though accurately defined, are too well known to our readers to merit recapitulation; and so we shall prefer to follow him in his very guarded *hints* at, rather than actual appraisement of, the military forces of the Crown.

Thus we can only guess from the italics used that the word "efficient," as used by the Volunteers, is regarded by the author as a certificate of

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good-will on the part of the Volunteer, rather than a clearly defined estimate of the man's competence as a soldier of to-day with to-day's requirements. The Volunteer Corps, we are told, leans upon its adjutant, who is the soul of the whole thing, while the selection of a "regular" officer as commandant of the regiment or corps would be an infringement of the rights and privileges of the officers of Volunteers. But the principal shortcoming in the system of training would seem to be that Volunteers as a mass are not regularly exercised with the regular forces. We might add that, if they did *so* exercise themselves, they would no longer be Volunteers, in the sense that what would make an "efficient" in point of time in the case of the Line would be a sheer impossibility in the case of the Volunteer.

It is however cheering to learn that fourteen days in camp *must* tend to partly justify the over-appreciation in which the Volunteers of a past day were held by the British nation, and to discount the dispraise with which foreign critics have regarded a movement, which, we now learn to our surprise, could have had but little influence upon strategists, who *should* have been deterred from attempted invasion by reason of our burgher army and its associated Militia.

Passing to the education of officers, we are told that they pass many examinations, which however are by no means difficult (from a German point of view). But difficult or not, the result is that the officer who leads our soldiery is warmly appreciated by a German critic, who in this instance speaks out, and in his favour, though regarding with a doubtful eye the Briton's love of sport and the extravagant glory of the "red coat." In this connection Lord Wolseley is held up as a type of the full development of the British officer, who has his opportunity and knows how to make the best of it, though incidentally we may remark that the writer does not include the great Field Marshal in the ranks of the perfervid sportsmen, who, to German eyes, form so marked a type in our much- criticised army.

Next in order our author treats some idiosyncrasies (as he regards them) in our national character, which produced the occasional "ragging" scandals and the like, and elicited (*pace* the writer) many objections on the part of officers on the active and retired lists to the drastic action taken by the authorities to protect the person of the commissioned officer.

And so in conclusion, for our space is limited, the writer covers much ground in descriptions of forms of training very familiar to us, of picturesque ceremonies in London (as for instance the Trooping of Colours and Relieving Guard), and impresses us with the accurate and attentive eye with which he has taken stock of our uniforms and of the methods we have adopted for assimilating our training to the teachings of modern warfare.

In fact, the author in the course of some fifteen pages has touched a great many questions, but has to a very great extent denied us the pleasure and interest with which we should have read his well-meant and no doubt able criticisms. Thus we should like to know what he really thought of the state of our army under the genial autocracy

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(modified and tempered by political interference) of him whom men are now beginning to remember as the *great* Duke of Cambridge; and whether he considers the oligarchy (tempered by supervision of the Secretary of State) known as the Army Council, more in keeping with our traditions; or in fine *what* is really the best form of government for our unique and peculiar armed forces, organised upon the principle of a voluntary army.

This and other such questions would, from the pen of an outside critic, have been even more interesting than the anomalies detected by our author in the supersession of officers in the field by others holding "local rank," or the descriptions of Aldershot and the Duke's monument, which, however, regarding the fact that the brochure in question was written for his compatriots rather than to benefit British readers by means of a critique from outside our ranks, lends local colour to a description of England and he rarmy which should be widely read by those for whom it has been so laboriously and carefully prepared.

F. C. ORMSBY-JOHNSON.

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NOTICES OF MAGAZINES.

JOURNAL OF THE SOCIETY OF ARTS.

Vol. LV. No. 2820. December 7th, 1906.

THE METRIC SYSTEM: SOME OBJECTIONS TO ITS COMPULSORY INTRODUCTION.—A Paper read by Colonel Sir Chas. Watson, K.C.M.G., C.B., late R.E.—The author commenced by reminding his hearers that both the British and the metric systems of weights and measures were legal in this country, the only compulsion being to accord with the standards kept by the Board of Trade; and that, since those who use the British measures are quite content with them, the public hears much of the arguments for the metric system but little against it.

The arguments usually brought forward in favour of the French measures may be summarised as follows:—

1. That the metric measures are thoroughly scientific, while the British measures are antiquated and unscientific.

2. That the metric measures are better suited both for ordinary and scientific use than the British, and that the decimal system of division is superior to the binary or to the duodecimal.

3. That the metric system has been fully adopted by most nations, and, therefore, its use would be very advantageous for British commerce.

As regards the first argument Sir Chas. Watson contributed a very interesting *résumé* of the history of the metric system.

Its original design and its present actual form are as follows:—

Original Metric System.	*Actual Metric System.*
1. The circle to be divided into 400° ; each degree into 100′ ; each minute into 100″.	1. The ancient division of the circle into 360° remains ; each degree being divided into 60′, and each minute into 60″.
2. The Mètre, the standard of length, was to be exactly $\frac{1}{10000000}$th of a quadrant of the earth's surface, measured from the North Pole to the Equator—*i.e.*, 1-10th of a new second of arc.	2. The Standard Mètre is slightly less than $\frac{1}{10000000}$th of the quadrant, and is, therefore, an arbitrary measure.
3. The Litre, the standard of capacity, was to be exactly equal to the cube of the tenth part of the Mètre.	3. The actual Litre is the volume occupied by the quantity of pure water which weighs exactly 1,000 Grammes. It is slightly larger than a cubic decimètre.
4. The Gramme, the standard of weight, was to be exactly equal to the weight of a volume of pure water, contained in the cube of the hundredth part of the Mètre. The kilogramme, or 1,000 grammes, was consequently to be the weight of the volume of pure water contained in the litre.	4. The Kilogramme, the actual standard of weight, is a platinum weight which was deposited in the Archives in 1799. It is slightly larger than the theoretical kilogramme, and is consequently an arbitrary measure. The actual gramme is the thousandth part of a kilogramme.
5. The Are, or standard of surface, was to be the square of ten mètres.	5. As the actual Mètre is slightly shorter than the true Mètre, so the Are is slightly smaller than the true theoretical Are.

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It will be seen from the above that all the metric measures differ from their true theoretical values, and depend upon two arbitrary measures, the standard mètre and the standard kilogramme, exactly in the same way as the British measures depend upon two arbitrary measures, the standard yard and the standard pound. It is clear, therefore, that the metric standards cannot be regarded as perfectly scientific or as superior, in this respect, to the British standards.

When these facts are pointed out to an advocate for the compulsory introduction of the metric system into England, the usual reply is, that the standards are nearly what they profess to be, and that the measures in themselves are better than the British, and that the decimal system of division is very superior to the binary or duodecimal. These points deserve careful consideration.

The British measures are founded on natural units, and have descended to us from a remote antiquity. The yard is the direct representative of what was probably the oldest measure in the world, *i.e.*, the cubit, which is the length of the forearm of a man of average stature, measured from the elbow to the top of the middle finger. A yard is two cubits. It is rather remarkable that, while in the case of the yard the derivation from the cubit is almost forgotten, the Indian "gaz," which is equal to the yard, is still divided into two "haths" or cubits. The foot is also a very ancient measure, and though it varied considerably in different countries it was usually about two-thirds of a cubit. The British yard is divided into 3 feet, or 36 inches. This number is divisible by 2, 3, 4, 6, 9, 12, and 18. The mètre on the contrary is divided into ten decimètres, each decimètre into ten centimètres, the latter being the nearest unit to the inch. There is no division of the mètre corresponding to the foot. The decimètre is too small to take the place of the foot as a unit, and it is little used. The absence of a unit of about the length of a foot is a blot on the metric system. Similarly, the inch is a better unit for ordinary purposes than the centimètre, which is too short, about $\frac{4}{10}$ths of an inch. The $\frac{1}{100}$th inch is better than the millimètre, as it is the smallest measure that can be seen conveniently with the naked eye, while the millimètre is too long.

As regards the decimal system of division, this is not a monopoly of French measures, and the British measures can be so divided by anyone who chooses to do so. But whereas in the French system, the decimal division only can be employed, in the British other fractional divisions are also applicable. For example, a carpenter prefers to use the inch divided into $\frac{1}{8}$ths and $\frac{1}{16}$ths; whereas for scientific and other accurate measurements it is better to divide the inch into $\frac{1}{10}$ths, $\frac{1}{100}$ths, and $\frac{1}{1000}$ths.

Similar reasoning is given to show that the metric system has no great advantage in the measures for weight and capacity; and the author deals with the fallacy that we now make difficulties for ourselves in relation to foreign trade with metric countries, many of which still retain some of their ancient measures. In the case of money, however, there is much to be said in favour of the decimal system.

Sir David Gill, Lord Kelvin, and others spoke more or less in favour of the metric system; and Major E. H. Hills, late R.E., aptly summed up

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the whole situation by saying, "The advocates of the metric system in the course of their arguments lapsed almost insensibly into an argument in favour of the decimal system. The author had quite rightly pointed out that the two should be most rigorously distinguished. Almost all the arguments, which had been used in the course of the discussion in favour of the metric system, were equally capable of being applied in favour of the introduction of a decimal system based on the English weights and measures. The only argument which remained was that of uniformity with the rest of the world. The present free system, where everybody was allowed to use those weights and divisions which most suited their particular trade, was the best for a free country. For scientific purposes, there was no doubt that the decimal metric systems presented very great advantages."

MITTEILUNGEN ÜBER GEGENSTÄNDE DES ARTILLERIE-UND GENIEWESENS.

December, 1906.

THE RUSSIAN ENGINEER EQUIPMENT FOR FIRING MINES ELECTRICALLY.

I. *Detonators.*

There are three types of detonators:—

(i.). A high resistance detonator.
(ii.). A cork detonator.
(iii.). A platinum detonator.

(i.). The High Resistance detonator (*Fig.* 1) has a resistance of 10,000 to 30,000 ohms. The priming composition consists of 52% potassium chlorate, 42% sulphate of antimony, and 6% powdered carbon. The electrodes are from ·04 to ·06 inches apart.

(ii.). The Cork detonator (*Fig.* 2), which was originally used as a makeshift, has a wire bridge, with a resistance of 500 ohms. The priming composition consists of mealed powder; this is kept in contact with the bridge by collodium, a solution of which is poured drop by drop over the powder. The length of the bridge is from ·12 to ·16 inches.

(iii.). The Platinum detonator (*Fig.* 3) has a resistance of about 1 ohm. Apparently this detonator is not definitely approved for the Russian Army, as there does not seem to be any type of exploder suitable for firing it. The bridge consists of a platinum wire with 15% of iridium in it. The priming composition consists of 50% of chlorate of potash, and 50% of yellow prussiate of potash. To fire this detonator a current of 1 ampère is required.

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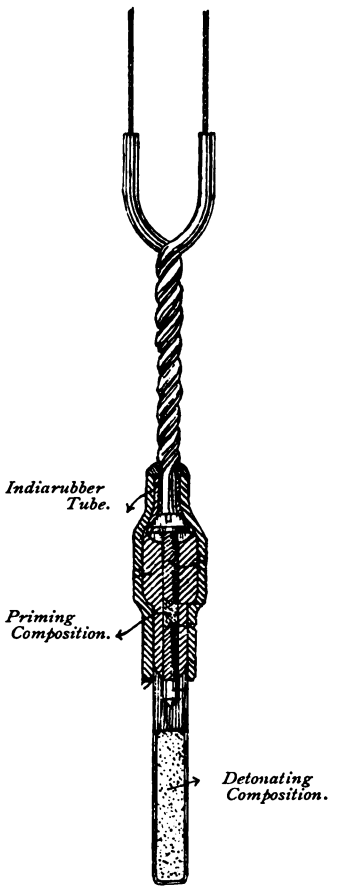

FIG. 1.—*High Resistance Detonator.*

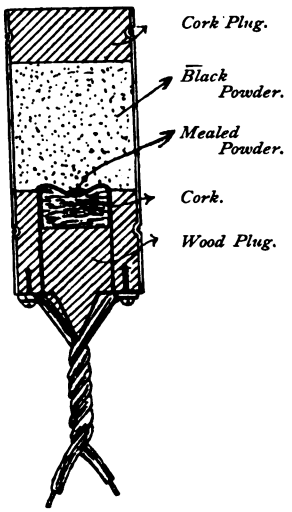

FIG. 2.—*Cork Detonator.*

FIG. 3.—*Platinum Detonator.*

II. *Firing Apparatus.*

These consist of:—

(i.). Siemens' Exploder.
(ii.). An Inductor.
(iii.). A Volta's Pile.

(i.). The Siemens' Exploder needs no description.

(ii.). The Inductor (*Fig.* 4) is a magnetic induction apparatus. A, A, A are horse-shoe magnets made of hardened steel, between the poles of which an armature can be rotated. By means of cog-wheel gearing this armature can be rotated at a rate of 24 revolutions to the second.

The coils of the armature have a resistance of about 500 ohms; and the current excited flows continuously through the outer coils; consequently, owing to the gradual increase of the current, a premature explosion of the more sensitive detonators may easily take place. The apparatus is therefore not reliable for firing detonators in series.

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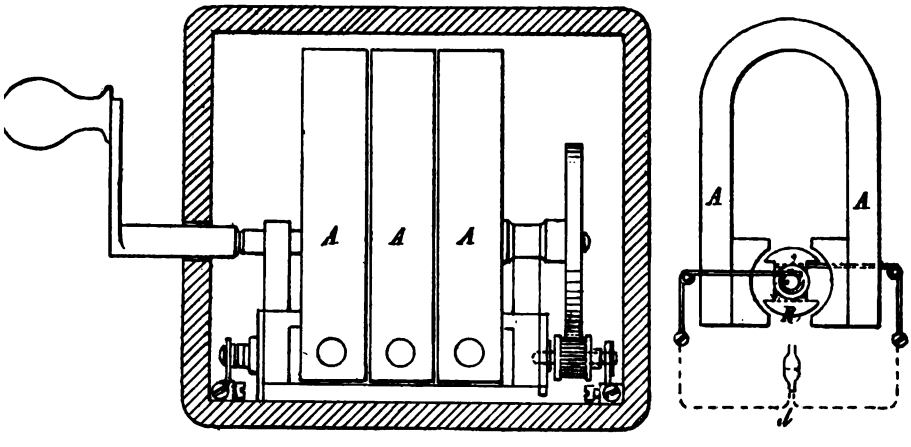
The E.M.F. developed by the Inductor depends on the external resistance. Experience shows that, if the armature is making 24 revolutions a second, the following E.M.F. is produced :—

External Resistance.	E.M.F.
1,000 ohms	70 volts.
500 ohms	45 volts.
250 ohms	30 volts.

As the High Resistance detonator requires at least 45 volts to explode it, the resistance of the circuit when using the Inductor must amount to at least 500 ohms

One advantage of the Inductor is that it weighs only $4\frac{1}{2}$ kilogrammes.



AAA Magnets. *Detonator.*

FIG. 4.—*Inductor.*

(iii.). The Volta's Pile (*Fig.* 5) is useful as a reserve apparatus. It consists of 100 pairs of zinc and copper plates, between each of which is placed a piece of cardboard soaked in sal-ammoniac solution. The plates are put into a wooden frame and pressed together with a wood screw. When freshly charged they have an E.M.F. of 80 volts and a current of $\frac{1}{4}$ ampère. The weight is about 74 kilogrammes.

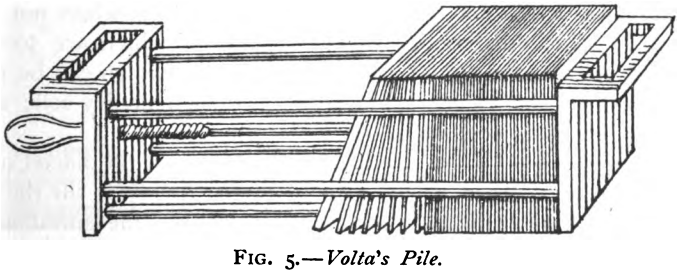


FIG. 5.—*Volta's Pile.*

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With this apparatus single detonators of high resistance and also cork detonators can be fired. Both E.M.F. and current soon fall off after the apparatus is brought into use.

III. *Leads.*

There are two kinds of leads, known as

(i.). Sapper leads.
(ii.). Single Strand leads.

The Sapper leads have a core consisting of seven strands of copper wire soldered together. The insulation consists of 3 layers of indiarubber; the layer next to the core is simple indiarubber, the second layer is a mixture of gum arabic and zinc oxide, and the outer is vulcanised indiarubber; over this last is wrapped linen tape. Twisted flax threads are plaited over the tape, after being heated with beeswax mixed with tar.

The external diameter is about $\frac{1}{4}''$. The resistance of 1 verst (about 1,200 yards) must not exceed 14 ohms.

(ii.). The Single Strand lead, as its name implies, has a core of a single strand of copper wire. The insulation consists of a layer of indiarubber, round which waterproof tape is wrapped. These leads are made up in coils of about 120 yards.

The resistance of 1 verst must not exceed 17 ohms.

To facilitate connecting up charges in divided, six-way connecting pieces are supplied, in which the ordinary lead branches out in to six leads, and these can be joined to the main lead at any point.

IV. *Test Cell and Apparatus for Measuring Resistances.*

The apparatus for measuring resistances (*Figs.* 6 and 7) consists of a galvanometer (*g*), a box of resistance coils (W, W_1), two terminals *k* and k_1 to connect up with the test cell, two terminals K K_1 for connecting up to the object of which it is desired to discover the resistance, and lastly the switches U and U_1. The internal connections of the different parts is shown in *Fig.* 6.

The coils of the galvanometer, which is in a revolving brass case, have a resistance of about 100 ohms. The magnet M (*Fig.* 7) is bell shaped, and is connected with an aluminium needle which shows the deflection obtained. The lever H, which is operated on by closing the lid of the case, keeps the needle in a fixed position when not in use. The resistance box has 6 coils, the resistances of which are 500, 1,000, 2,000, 5,000, 10,000, and 30,000 ohms, any or all of which can be put into circuit. The test cell is very similar to the Leclanché dry cell; and has an E.M.F. of 1·4 volts and a resistance of 2 ohms.

Use of Apparatus.—The apparatus when used must be placed on a flat base, and the brass case of the galvanometer revolved till the needle points at 0. The test cell and the resistance to be measured are then connected up in the circuit.

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The resistance can be measured in two ways:—

(*a*). By comparing it with the resistance coils. For this purpose the current is first switched to the object whose resistance is to be found, and the deflection on the galvanometer noted. Then the current is passed through the resistance coils, the deflection on the galvanometer for the various resistances being noted. From a comparison of these the resistance to be found is estimated.

(*b*). By calculation from the number of degrees of deflection on the galvanometer, for which purpose a special table is supplied. This method gives a result correct within 5%.

Test Cell and Resistance Measure.

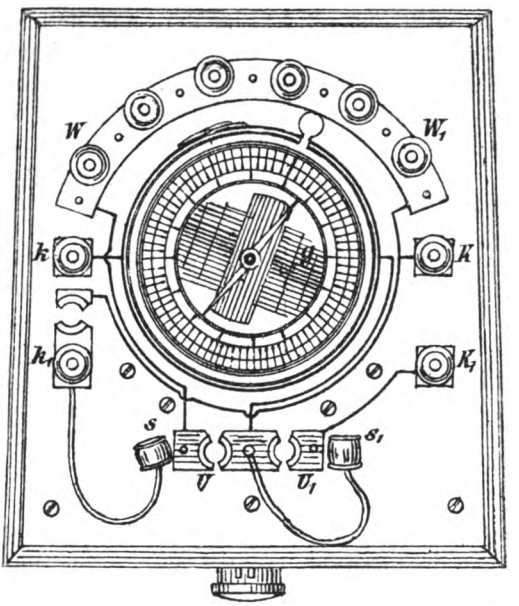

FIG. 6.

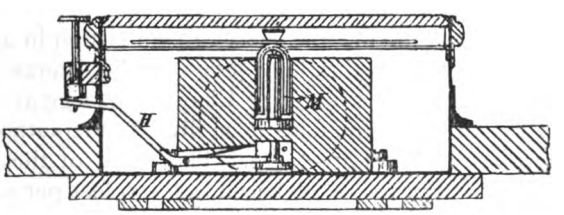

FIG. 7.

V. *Equipment of a Sapper Company.*

The equipment for each Engineer Company consists of:—1 inductor, 1 exploder, 1 galvanometer and box of resistance coils, 1 test cell, about ¾ mile of sapper leads on 3 drums, 220 yards of single strand leads in 2 coils, 4 six-way junction pieces, 220 detonators.

C. OTLEY PLACE.

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NATURE.

December, 1906.

WIRELESS TELEGRAPHY (*p.* 134).—Experiments, carried out between Landi Kotal and Peshawur, have demonstrated the fact that the interposition of higher mountains does not interfere with free communication between two places in a mountainous country.

THE MICROPHONE PRINCIPLE (*p.* 153).—An ingenious application of the microphone for the detection of fire-damp has been made in France. If the sound waves of two pipes of equal pitch impinge on microphones connected in series with a telephone, a clear note is heard; but if one of the pipes emits a but slightly different note, there will be beats heard in the telephone. Now if one pipe is on the bank and the other underground, the latter, if there be fire-damp, will be blown with air of a different density and emit a different note. The telephone will then, by sounding beats, give warning of the presence of fire-damp. The apparatus, when tested with coal gas, showed great sensitiveness. An admixture of but 0·1 per cent. gave three beats in twenty seconds, and an admixture of 1 per cent. gave thirty beats in twenty seconds.

"ARTILLERY AND EXPLOSIVES" (*p.* 174).—By Sir A. Noble.—When the author first joined the Royal Artillery, the heaviest gun in use was a cast-iron weapon weighing 95 cwt. and firing a 68-lb. round shot with a muzzle velocity of 1,600 feet per second. When, later, officers of the R.A. were pressing for the introduction of a naval gun weighing seven tons, the naval officers "doubted whether so heavy a gun could be carried on board ship," and a compromise was effected by introducing a gun of 6½ tons. Yet we have had vessels, the *Sans Pareil* and *Benbow* (both long since obsolete), carrying two 110-ton guns!

When Noble and his colleague Sir F. Abel first took up the examination of gunpowder, the knowledge on the subject was simply chaotic; the most diverse ideas, as to the pressure and temperature developed on firing, were held; charges occupying but a small portion of the space in the experimental vessel had been employed; and it was not until they succeeded in retaining all the products of combustion in a space which the charge completely filled, that knowledge on the changes commenced to have any claim to scientific accuracy. Charges so large as 23 lbs. of gunpowder and 5 lbs. of guncotton have been fired in the author's explosion vessels, illustrations of which are given. The result of these researches was that velocities in guns were advanced to 2,100 feet per second.

The advantages of a smokeless powder are so great that as soon as the difficulty of "taming" gunpowder had been overcome, its adoption, either gelatinised alone or mixed with nitro-glycerine, quickly followed. Again Noble and Abel were pioneers in our knowledge of the conditions attending the use of smokeless powders; changes involved during their combustion are less complicated than those with ordinary gunpowder. The influence of increasing amounts of nitro-glycerine to nitro-cellulose in cordites was first fully worked out by Noble, who showed that erosion in

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guns is due to two causes—(*a*) high temperature of the products, (*b*) the motion of these hot gases—and that increase of temperature went hand-in-hand with increase of nitro-glycerine and consequently also the erosion.

The new M.D. cordite contains only 30 per cent. of nitro-glycerine instead of 58 per cent. as in the earlier form. Powder of this composition will, for the same charge and size of cord, give less energy in the gun, but this may be overcome by suitable modification of the charge and size of cord.

ANTI-MALARIAL MEASURES (*p.* 204) were commenced at Ismailia in 1903, since which no fresh cases of malaria have occurred; before the anti-malarial campaign there had been from 1,500 to 2,500 cases per annum.

At Port Swetenham, Malay States, anti-malarial measures were commenced in 1901–2. Among the Government employés in 1901, 236 sick certificates were issued and 1,026 days of leave were granted on account of malaria. In 1905 the figures were respectively four and thirty. Comment is needless.

W. E. WARRAND.

PROCEEDINGS OF THE SOCIETY OF ANTIQUARIES OF SCOTLAND.

Vol. XL., pp. 136—150.

ON VITRIFIED FORTS: With Results of Experiments as to the Probable Manner in which their Vitrification may have been Produced, by Lieut.-Colonel A. B. McHardy, C.B., late R.E., Vice-President.—Scattered along the Caledonian Valley, along the great line of Lochs between Inverness and Fort William, and beside the margins of the broad arm of the sea known as the Sound of Arisaig, are many curious rudely-built Forts constructed of native stones.

These Forts are considered to have been built by the hands and after the designs of a long vanished and primitive people. Amongst the stones forming their somewhat massive ramparts may be seen varying numbers of similar local stones which are cemented together in places by a lava-like substance, thus assuming the appearance of vitrified conglomerates.

Colonel McHardy has set himself the arduous task of endeavouring to account for this peculiarity in ancient Fort building, to unravel the origin of the works and the purpose or purposes which they served, and to discover if possible the inner meaning of the Vitrified Stones and their uses. This he has signally achieved by the aid of sound military constructional and scientific knowledge. He has devoted his leisure time during a space of 5 years to this object, and right well has he accomplished his unremunerative, self-imposed task.

The theories hitherto advanced to account for the existence of these

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stones in the Forts well show the mysteries which have surrounded them; by some, the vitrification has been considered to have incidentally arisen as the result of Beacon Fires, or great fires for Religious or other purposes; by others, of fairly equal authority, the vitrification is believed to be the intended result of a structural strengthening of the parapet walls by fusing its component stones into an interdependent mass. Colonel McHardy, calling science to his aid, has taken the pains to verify, by actual experiments and chemical analyses, what kind of process applied to the various natures of stones in the vicinity of the Forts is capable of producing the particular form of vitrification observed.

The importance of the subject is evidenced by the fact that vitrified materials used in Forts have been discovered in Ireland, Germany, Austria, and France, the matter, therefore, being one of cosmopolitan interest to all, and not limited to those to whom the History of the Scottish Race is somewhat more than a mere phase of passing fancy.

By a series of carefully-conducted experiments in stone burning, utilising such varied fuel as grass, straw, wood, bracken, peat, brushwood, sea-weed, etc., afterwards analysing the residual slag and observing fluxes, much valuable information has been obtained on the subject of vitrification.

The net deductions are that vitrification of the stone to the extent required does not result from a too rapid conflagration fanned by an active draught of air. But by placing wood fuel below the stones, heaping on wood and stones alternately in a smouldering smothered fire of great intensity, whilst checking the consumption of fuel as much as possible, after some 18 hours, the hot pile having meanwhile risen to a height of 4 feet, a vitrified block weighing 8 lbs. was artificially evolved. The probability is that the vitrification of Fort materials was originally brought about by their primitive constructors in much the same fashion, the rate of combustion being reduced, whilst the heat was conserved.

The author likewise suggests that in these isolated Forts a long-continued smouldering fire, capable of being stirred up at any time, would be a matter of necessity, being available for signalling purposes as well as in constant use for cooking food. Such an arrangement is now said to be in vogue in some of the Pacific Islands, and appears also to have been a common custom in Prehistoric Kentish and Surrey defended village oppida settlements.

Incidentally he deduces the facts that the Fort defenders were not in the habit of assuming that they had undeniable Command of the Sea, and that their visual lines of communications between the scattered Forts were admirably adapted to give early information as to the movements of a probably hostile sea rover appearing on the scene at an inopportune moment.

The whole Paper can justly be said to be a masterly exposition of a very probable solution of a much vexed, complex question; the subject is treated with great scientific insight, and the Paper seems likely to become the standard record for all time on the mysterious art of vitrification as applied to ancient Fort construction.

O. E. RUCK.

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REVUE DU GÉNIE MILITAIRE.

November, 1906.

DIRIGIBLE BALLOONS.—A continuation of the article published in the previous numbers. The discussion on propeller designs is concluded. Petrol motors are the only form of engine now used in dirigible balloons. They can be constructed to weigh from 6½ lbs. per horse-power. The latter part of the article is devoted to the history of dirigible balloons.

DEDUCTIONS FROM THE SIEGE OF PORT ARTHUR.*—These are derived from the articles published by Capt. von Schwarz of the Russian Engineers in the *Eenzhenernee Zhoornal.*

The position at Nanshan is described in detail, and a large scale plan of it is given. Twelve batteries and two infantry redoubts were constructed on this position by the Russians in 1900. Just before the outbreak of war, it was decided to add a number of infantry trenches and two more batteries, and to provide bombproof shelters. In the end the hill was surrounded by two, and in some places three, tiers of trenches, supported by 15 batteries, 4 redoubts, and 5 lunettes. In front of the trenches was an almost unbroken line of wire entanglements. The gaps in the line were filled with fougasses. The walled town of Kinchow, which lies in front of Nanshan, was occupied by a small garrison, which did not exceed 400.

The Japanese attacked the town on the 21st, 23rd, and 25th May, and were on each occasion repulsed with heavy loss. On the night of the 25th they surrounded and captured the town, after some severe fighting.

On the morning of the 25th the Japanese artillery opened fire on Nanshan; and though they inflicted no loss, they drew the fire of the Russian guns. On the 26th the Russian trenches were occupied by 8 companies of the 5th Regiment, with 3½ companies and 2 detachments of skirmishers in support. The general reserve consisted of 4 regiments, one being on the right flank, one in the centre, and one on the left, with the fourth near the railway station of Nangalin. There were also 6 batteries in reserve. The Japanese had 230 field and 20 siege guns, nearly all quick firers, against a total of 60 Russian guns, of which only 12 were Q.F.; the Russians had only 150 rounds per gun. The Japanese guns opened fire at 4.30 a.m., and very soon established their superiority. By 9.30 a.m. most of the Russian guns had finished their ammunition, and at 11 a.m. the last battery ceased fire. The Japanese infantry, supported by their artillery and by the fire of their gun-boats, were then able to advance against the Russian left flank. They gradually pushed it back, and at about 5 p.m. their advance was facilitated by the retirement, owing to a mistaken order, of some of the Russian infantry from the trenches on the left centre. By 8 p.m. the whole position had been captured.

* A *précis* of Capt. von Schwartz's article, by Major F. E. G. Skey, R.E., was published in the *R.E. Journal* of July, 1906.—ED.

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The Russian defeat was due to the following causes:—(1) They had only 2,400 men to hold 7,500 yards of entrenchments; (2) their general reserve was unnecessarily large, and the greater part of it was never engaged; their guns had only 150 rounds each; (4) the defences on the left flank were completely destroyed by the fire of the Japanese gun-boats.

As regards field entrenchments in general, Capt. von Schwarz lays down the following conditions which should be satisfied:—(1) The soldier should be able to fire comfortably; (2) he should be protected from rifle and shrapnel fire; (3) he should be secure against enfilade fire; (4) the works should be invisible; (5) the trenches should be wide enough to allow troops to pass along them without disturbing the firing line; (6) there should be covered communications with the neighbouring trenches and with the reserve.

The type of trench which the Russians found most satisfactory was about 3 feet wide, with the rear half 18 inches deeper than the front, thus providing covered communication behind the firing line. The parapet was furnished with embrasures for two or more rifles; and overhead cover for the firing line was provided by means of thick planks laid on pickets driven into the inner face of the parapet and projecting about 18 inches over the trench. If possible every trench should be 4 ft. 6 in. deep, and should have no parapet; but if more command is required to obviate dead ground, a parapet must be used. In permanent fortifications, which are likely to be subjected to the fire of heavy siege guns, raised parapets must be dispensed with.

Dead ground must be filled in, or must be under the effective fire of some other work.

Fire trenches should not be continuous, especially if the garrison is weak. A separate trench or group of trenches should be provided for each unit, with a covered trench leading to a main communication trench in rear, the latter being roughly parallel to the front of the position. A space of 150 to 250 yards of front may be left between the groups of fire trenches. The main communication trench should be from 350 to 400 yards behind the fire trenches, so that shrapnel fire aimed at the latter shall not sweep the former.

The reserves should be posted under cover in rear of the main communication trench.

Short lengths of mine gallery form the best bombproof shelters.

As regards the arrangement of redoubts and trenches, the writer considers that strong lunettes should be placed a little in front of the fire trenches, so that they can flank the latter. The enemy will then be forced to capture the lunettes before they can gain a footing in the trenches. As far as possible the interior of each work and trench should be exposed to the fire of works in rear, so that they may be rendered untenable by the enemy. Closed works should only be allowed in the rearmost line of defences. All parapets or trenches exposed to enfilade fire should be recessed.

In calculating the size of works, the author deducts one third of the whole garrison to form a reserve, and then allows a length of parapet of 7 ft. 6 in. per man on the front and flanks for the remainder.

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A type of battery, which was found very useful at Port Arthur, consisted of two or more emplacements, excavated to the full depth. These were placed some distance apart, and were connected by a mine gallery, which served as an ammunition store and shelter. The excavated earth was painted—presumably with some sort of colour wash—to match the surroundings. Batteries should be protected by infantry entrenchments, situated at least 350 yards away on the front and flanks.

Wire entanglements proved to be the most efficient obstacles. They should be concealed from the enemy in ditches or low ground. The enemy should not be able to locate the position of any gaps which may have been left in the entanglement for a counter-attack. Planks studded with spikes were placed on the parapets of some of the works at Port Arthur, and proved a very efficient obstacle. Fougasses in a single line are useless; they should be placed in several rows, one behind the other, near the entrenchments, so that the defenders may counter-attack before the enemy has recovered from the effects of the explosion.

In conclusion Capt. von Schwarz states that defence works designed and executed in haste are of little use. When time is short, only a few works should be undertaken; but these should be completed in every detail.

J. E. E. CRASTER.

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RECENT PUBLICATIONS.

The Battle on the Scha Ho. Authorized translation by Karl von Donat of the August, 1906, Supplement to the *Militär Wochenblatt*, with "Comments on the Battle" by Lieut.-General von Caemmerer. (8½ × 5½. Rees).

Achtzehn Monate mit Russlands Heeren in der Mandschurei. Band I. Vom Beginn des Krieges bis zum Rückzuge nach Mukden. Von Major F. v. Tettau. (8.50 mks. Mittler, Berlin).

Critique Stratégique de la Guerre Franco-Allemande. Les Armées en Présence, par Lieut.-Colonel A. Grouard. (8vo. Paris).

Die Schlacht der Zukunft, von Major v. Hoppenstedt. (3.60 mks. Mittler, Berlin).

Die Feldverschanzung. I. Teil. Grundzüge der Führung. Aus den Kriegslehren grosser Feldherren. Von Oberstleut. Julius Mener, Instruktor der Genietruppen. (3.50 frs. Bern).

The Nation in Arms, by Baron C. von der Goltz. Translated from the 5th German edition by P. A. Ashworth. (8½ × 5½. Rees).

Commerce in War, by L. A. Atherley-Jones, K.C., M.P., assisted by H. H. L. Bellot. (10 × 6. 21s. Methuen).

Geschichte des preussischen Ingenieur-und Pionierkorps von der Mitte des 19. Jahrhunderts bis zum Jahre 1886. Band II. Die Zeit von 1870 bis 1886. Bearbeitet von Oberstleut. H. Frobenius. (6 mks. Remier, Berlin).

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Sanitary Engineering with respect to Water Supply and Sewage Disposal, by L. F. Vernon-Harcourt. (9 × 6. 14s. Longmans, Green).

Garbage Crematoria, by W. M. Venable. (8s. 6d. Chapman, Hall).

Mechanics of Materials, by Mansfield Merriman, Professor of Civil Engineering, Lehigh University. 10th edition. (21s. Chapman, Hall).

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,, G. C. Merrick, D.S.O., R.G.A.
,, W. H. Moore, D.S.O., R.G.A.
,, J. P. Mackesy, R.E.
,, B. W. B. Bowdler, R.E.
,, F. D. Farquhar, D.S.O., Coldstream Guards.
*Capt. R. G. Parker, Rl. Lancaster Regt.
Capt. G. N. T. Smyth-Osbourne, Devonshire Regt.
Capt. V. H. M. de la Fontaine, East Surrey Regt.
Capt. and Bt. Major F. R. Hicks, Hampshire Regt.
Capt. H. S. Williams, Dorsetshire Regt.
,, B. D. L. G. Anley, D.S.O., Essex Regt.
Capt. R. S. Hamilton-Grace, Durham Light Infantry.
*Capt. H. F. Baillie, Seaforth Highlanders.
,, P. S. Allen, Gordon Highlanders.
,, J. K. Cochrane, Leinster Regt.
,, R. L. Ricketts, Indian Army.
,, W. K. Bourne, Indian Army.
,, F. W. Lumsden, R.M.A.

The following Officers received nominations:—

Capt. H. C. Bickford, 6th Dragoon Guards.
Capt. C. J. C. Grant, Coldstream Guards.
Capt. W. D. Wright, V.C., Royal West Surrey Regt
Capt. C. H. Harington, D.S.O., Liverpool Regt.
Capt. H. Wake, D.S.O., King's Royal Rifle Corps.
Capt. and Bt. Major N. J. G. Cameron, Cameron Highlanders.
Capt. G. P. Grant, D.S.O., Indian Army.

SANDHURST, JUNE, 1906.

FIRST	A. G. Armstrong	5,541	129th	R. P. T. Ffrench	3,827
48th	H. G. Gauntlet	4,515	181st	C. W. Molony	3,445
67th	D. Macdonald	4,299	186th	P. J. I. Synnott	3,386
89th	W. G. Bagot-Chester	4,115	190th	R. M. Aylmer	3,339
90th	A. G. Ottley	4,109	197th	O. Gough	3,262
93rd	A. P. Williams-Freeman	4,094	201st	P. W. J. A. Stomm	3,151
115th	D. M. Black	3,940	213th	B. W. Molony	2,881
125th	W. J. King-King	3,846			

WOOLWICH, JUNE, 1906.

31st ... ... J. S. Barkworth 6,483

DECEMBER, 1905.

SECOND	H. G. MacGeorge	7,196	16th	R. Crofton	6,330
FOURTH	G. Walton	7,046	45th	D. Stephenson	5,899
FIFTH	H. A. Cox	6,967	54th	J. Kennedy	5,711

This was the First Examination under the new regulations, and our pupils secured THREE out of the first FIVE places.

MILITIA COMPETITIVE, MARCH, 1906.

A. E. Hardy	2,304	W. F. Anderson	1,947
N. H. Hutcheson	2,105	D. C. Robinson	1,879
F. D. Frost*	1,949	F. A. Bowring	1,876

*Read partly at the Army College, Aldershot.

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Nineteen passed.

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ERRATUM.

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Journal of the Royal United Service Institution. By Major A. T. Moore, R.E. 184

Revue du Génie Militaire. By Capt. J. E. E. Craster, R.E. 191

Revue Militaire des Armées Étrangères. By Capt. J. E. E. Craster, R.E. ... 192

Rivista di Artiglieria e Genio. By Col. Sir E. T. Thackeray, V.C., K.C.B., late R.E. 193

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SUGGESTIONS FOR THE EMPLOYMENT OF R.E. FIELD COMPANIES DURING FIELD TRAINING AND MANŒUVRES.

By Bt. Col. J. L. Irvine, R.E.

The employment of Royal Engineers during field operations should approximate as nearly as possible to their duties on active service.

For R.E. Field Companies these may be divided into three heads:—

1. Duties on the Line of March.
2. „ in Camp or Bivouac.
3. „ in Attack or Defence.

Duties on the Line of March.

1. Under the first category may be included the following:—

(*a*). *During an Advance.*

Clearing obstacles or roads, through woods, etc.
Bridging streams, rivers, ravines.
Repairing bridges.
Constructing and repairing roads; making roads across swamps or bogs.
Improving communication generally.
Repairing railways, clearing tunnels.
Improving fords.
Arranging temporary water supply.

(*b*). *During a Retreat.*

Creating obstacles to a pursuit, such as felling trees (by tools or explosives) across roads, tracks, etc.
Making wire entanglements.
Digging pits.
Destroying bridges and culverts.
Obstructing fords.
Flooding low-lying ground by damming streams.
Laying mines and fougasses.
Blowing in or blocking tunnels.
Destroying railways and telegraphs.
Arranging temporary water supply.

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DUTIES IN CAMP.

2. The principal duty of R.E. in camp is water supply. This may include :—

Arrangement of temporary water supply by hand or steam pumps.
Storage of water.
Construction of filters.
Distribution of water in a permanent camp by laying lines of pipes and erecting standpipes.

Other duties include :—

Construction of roads and paths.
Improving drinking and washing places.
Improving fords.
Constructing huts and shelters.

Also, in a camp of a permanent nature :—

Constructing hospitals, remount depôts, latrines, cemeteries, etc.

DUTIES IN ATTACK AND DEFENCE.

3. (*a*). In *Attack* the R.E. would be employed in :—

Removing obstacles.
Blowing in gates and doors.
Blowing up walls and stockades.
Entrenching important points, such as hills, defiles, villages, and farms seized during the attack.
Removing mines.
Constructing counter-mines.
Erecting obstacles or defence works to provide against a counter-attack.

(*b*). In *Defence* :—

Blocking roads and approaches.
Destroying bridges and culverts.
Superintending clearance of woods.
Clearing field of fire.
Constructing obstacles, alarms, and flares.
Laying mines.
Measuring ranges.
Constructing defences and posts on specially important points.
Constructing and superintending construction of field defences.
Improving internal communications.
Preparing the way for a counter-attack by removing obstacles.
Arranging water supply.
Laying tram lines.
Sanitary and hospital services.

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(*c*). In case of *Sieges* the general arrangement and construction of siege works both in attack and defence.

From the above it will be seen that the duties of Royal Engineers in war time are usually of a constructive or destructive nature, which are in most cases impossible to carry out during peace manœuvres. But a great deal can be done by arranging for the R.E. company to theoretically carry out constructive or destructive work by means of reports and drawings.

It is rare in peace manœuvres that a force retiring or advancing will take notice of such small features as a bridge or culvert over a stream, one of the reasons usually given being that to carry out the demolition or reconstruction would delay the remainder of the troops too much; but a broken bridge or culvert is of considerable importance in actual warfare and cannot be neglected. The demolition could be theoretically carried out by detailing the actual R.E. and infantry party (with covering party if necessary) for the work and sending them off to the site; the O.C. would then draw up his scheme, make up dummy charges and actually fire them, and on completion leave a notice stating the hour at which the demolition was carried out and the nature of the damage done.

The demolition party could then rejoin the remainder of the force, which in the meantime would have continued its march; and the O.C.R.E., on the termination of the manœuvre, would hand in to the umpires his report of the demolition, with drawings, details of charges, etc.

Similarly, if the attacking force found its advance blocked by a broken bridge, etc., the R.E., with working and covering parties, could be sent forward and the work could be arranged by the R.E. without stopping the remainder of the force.

The report and drawings would show the work done, the umpires would be able to criticise them just as well as if the reconstruction had actually taken place, and the R.E. would have had useful practice.

Attached are two memos on the subject, giving further examples of work that would be possible, which have been issued at Aldershot for the guidance of R.E. field units.

It is too frequently the practice during field operations to employ the R.E. solely on water supply arrangements when in camp, and during actual manœuvres to leave them in reserve or to employ them in laying out or digging trenches on some hill well in rear of the line of operations. As the R.E. company on service would probably number few more than 100 rifles the amount of entrenchment they could do would not be great, and in actual warfare the duty of entrenching must fall to the infantry, with or without R.E. superintendence. It is therefore wrong to employ R.E. during peace manœuvres on entrenching a useless piece of ground.

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During field operations useful instruction could be given by detailing R.E., with the necessary covering and working parties of infantry, to carry out *theoretically* such duties as the following, reports and drawings of the work done being furnished to the umpires in each case :—

Demolition and reconstruction of bridges, culverts, railway tunnels, etc.

Construction and removal of obstacles on roads or in front of a position.

Clearing field of fire.

Entrenching or preparing for defence specially important points (such as a village, farm, or hill) in, or in rear of, the main line, which may be useful as rallying points or *points d'appui*.

Temporary water arrangements.

Actual work may sometimes be done in improving a line of approach for wagons across boggy or marshy ground, improving drifts or watering places, constructing temporary pontoon, trestle, or spar bridges. In the case of a skeleton enemy it would be an advantage to have a R.E. officer and a few men with it to arrange demolitions, etc.

Should the proposed organization (2 Field Companies to a Division, under a senior officer as O.C.R.E.) be approved, the O.C.R.E. should in all cases accompany the Division during Divisional and Army Corps Training; and he would be able to advise as to the most suitable employment of the R.E. Companies under the circumstances.

ARRANGEMENTS FOR EMPLOYMENT OF ROYAL ENGINEERS DURING WINTER MONTHS.

TECHNICAL WORK.

1. One unit will be detailed weekly for a march out and technical day under its O.C. A scheme will be prepared by the O.C. unit and a copy will be forwarded to the Orderly Room by 12 noon the previous day. A report on the work carried out will be forwarded to the O.C.R.E. on the following day.

2. The following schemes are suggested :—

Selection of position for brigade or division on previously unreconnoitred ground.

Destruction of railways, including demolition of bridges, tunnels, etc., or flooding of railway on low-lying ground.

Hasty watering arrangements for a division or brigade of cavalry.

Clearing woods, etc. (probably actual clearing of brushwood and felling timber could be carried out by arrangement with the C.R.E. Lands).

Defence of villages and houses.

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3. In carrying out these technical schemes every effort will be made to make the work as realistic as possible.

For instance :—

(*a*). In carrying out demolitions the O.C. unit should tell off a party for the work with the necessary tools, and the officer in command of the party will set to work in as practical a manner as possible.

He will carefully consider the nature of the demolitions to be carried out, make up a dummy charge, place it in position, fix a detonator, and actually fire it. He will make a rough sketch of the object of destruction, giving accurate dimensions, calculate out the charge, and show in his sketch and report how he actually proposes to hold the charge in position and the expected effect of the explosion.

(*b*). In preparing a house or village for defence, the officer should make a sketch of the works he proposes, give details of working parties, list of tools, time required for completion ; and should not undertake, or assume that he can carry out, work for which he has neither men or tools.

(*c*). In repairing bridges he should only make use of the tools and materials available, and should state in his report from whence the material is obtained.

(*d*). If he is required to build redoubts or field works, and he is not allowed to break ground, he will design and trace out the work, lay out tools, and extend his men in their actual position for work.

He should only construct obstacles for which he has time and materials.

4. The mounted portions of units should, as far as possible, take part in the general scheme, or, if this is not feasible, opportunity should be taken for instruction in driving drill and reconnaissance work.

5. The unit detailed for technical work will arrange for dinners to be taken out and cooked, or for supply of soup, etc.

INSTRUCTIONS FOR R.E. UNITS WHEN EMPLOYED IN FIELD OPERATIONS.

1. When R.E. Units are employed in field operations, and are detailed to carry out duties which it is impracticable to perform in peace, but which would be necessary in war, they will use every effort to make the work as realistic as possible.

2. For instance, in carrying out demolitions the O.C. unit should tell off a party for the work with the necessary tools, and the officer in command of the party will set to work in as practical a manner as possible.

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He will carefully consider the nature of the demolitions to be carried out, make up a dummy charge, place it in position, fix a detonator, and actually fire it.

He will make a rough sketch of the object of destruction, giving accurate dimensions, calculate out the charge, and show in his sketch and report how he actually proposes to hold the charge in position and the expected effect of the explosion.

He will, if asked for it, hand in the sketch and report to the umpire, or, failing this, will send it in to the Orderly Room on return to barracks.

3. In preparing a house or village for defence, he should make a sketch of the works he proposes, give details of working parties, list of tools, time required for completion ; and should not undertake, or assume that he can carry out, work for which he has neither men nor tools.

4. In repairing bridges he should only make use of the tools and materials available, and should state in his report from where the material is obtained.

5. If he is required to build redoubts or field works, and he is not allowed to break ground, he will design and trace out the work, lay out tools, and extend his men in their actual position for work.

He should only construct obstacles for which he has time and materials.

6. If required to defend a position in conjunction with infantry, the R.E. would probably be employed on the more technical parts of the defence, the infantry, unassisted, carrying out the actual trench work.

But if, during field operations, the G.O.C. under whom they are employed should wish the R.E. to combine with the infantry in digging entrenchments, the most suitable way of employing the sappers would be to dig short lengths of trench, at intervals between the infantry parties, which would serve as a pattern to the other troops.

7. It is probable, however, that R.E. would not be employed in actual trench work, and they might then be usefully occupied in constructing obstacles in suitable positions, clearing the field of fire, arranging communications, etc.

8. In wooded country the operation of clearing the field of fire is a very difficult one, and in making calculations officers are apt to be too sanguine as to the pace at which it can be done.

When trees are felled they must be dragged or carted away, as their leaves, branches, and trunks afford both concealment and cover to the enemy.

In making hasty clearings it would probably be better to lop and burn the lower branches, and only to fell trees where it is desired to block roads or other lines of approach.

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THE ECONOMY OF COAST DEFENCE.

By Col. S. A. E. Hickson, d.s.o., R.E.

We have been told by the Navy that fortifications, submarine mines, and fixed defences generally are, for the most part, useless and expensive luxuries. Is there not good reason, just at the present time, to enquire why a separate Coast Defence Service has been called into existence. Why has a new name been given to what at present are merely the harbour defences of our naval bases, and are strictly speaking not an organised system for the Coast Defence of our Island Fortress? Is not an organised system possible on entirely new lines, especially suited to the characteristics of our country and people?

The sphere of the Navy is understood to be free and unfettered action at sea; likewise the sphere of the Army is understood to be free and unfettered action on land. The sphere of Coast Defence then I conclude to be to keep touch between the Navy at sea and the Army on land, by watch and ward along our shores. Acting along our coasts as the best possible line of resistance to the enemy, and protecting the shores, ports, and commercial towns of the mother country against surprise raids, Coast Defence should set our Navy absolutely free for action on the sea and our Field Army free for service abroad, by defying disembarkation.

This at least would seem to be the natural conclusion to be deduced from the contest which has once more been raging as to the functions and sphere of action of the Navy, and which has ended in a way so satisfactory to most people. That is to say the knell of the "dinghy school" has been *tolled*. To paraphrase a famous pun, it has been *told* that it is not credited; it has been ding-donged out of existence. The primary duty of the Navy, we are now distinctly informed, is to keep open our communications and look out for being strong at the essential strategic point, rather than to prevent raids. The air has thus been cleared; and I would invite those who would clear their brains on this matter to study with care both the recent lucid and instructive articles of Sir Cyprian Bridge (see *Morning Post*) and still more the very able expositions of Capt. Slade, R.N., of the Naval College. The lecture by the latter, published in the *R.E. Journal* of April, 1906, is well worth reading with the greatest care line by line. I have done so myself and have had the further great advantage of attending some of his lectures at the Naval War Course at Plymouth.

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Whether we study Capt. Slade or Sir Cyprian Bridge (who writes as representing the Blue Water School) or other naval experts, all alike seem now agreed. The Navy cannot guarantee the prevention of raids. Even raids in considerable force may be made by troops numbering, possibly, even 20,000 or 30,000 men. Sir Cyprian especially tells us that, outside the dinghy school "no one asserts or ever has asserted that raids in moderate strength are not possible even in the face of a strong defending Navy.* It is a fact that the whole of our policy for many generations has been based upon an admission of their possibility." Capt. Slade tells us, even still more plainly, that raids cannot be prevented, though he seems to have in view raids of somewhat more modest dimensions. But if the Navy cannot prevent raids who is to do so, if it be not our Coast Service? What a warning is here held up to the, meantime, slumbering and unconscious inhabitants of our coast!

Where is our organised system of Coast Defence, and how are we to begin to construct it?

We have no desire to trespass upon the sphere and functions of the Navy, which is, of course, and must always remain our first line of defence, keeping open our communications and keeping in view the main strategical objective of the moment. This may, however, take our fleets away from our shores, and an opportunity for a raid may then be given. Even though such a raid should not actually occur, if distant strategical operations render necessary the absence of our fleet, in such a case (as Lord Rosebery asks) will the inhabitants of our commercial ports and coast cities be content to remain at home, and there receive a prospective visit from several thousand foreign visitors? Will they not rather desire to receive them at the muzzle of their own guns? This being so, in what manner and by what means should our Coast Defence be conducted. Let us endeavour to ascertain where its duties begin and where they end?

Elaborate land fortifications or coast defences are, I believe, rightly doomed as far as this country is concerned, notwithstanding the experience of Port Arthur. Powerful and costly works, with deep ditches, escarp and counterscarp galleries, and caponières, exceeding even modern battleships in cost, are in our case no longer necessary. On the other hand the development in range and accuracy of artillery fire during the last ten years has been prodigious. Heavy guns mounted on land can to-day altogether defy battleships. "The effective range of well-placed heavy guns against ships may be taken as about 15,000 yards" (see Capt. Slade's article in *R.E. Journal*). Capt. Slade further tells us that it is not necessary to have very many of these guns but that there should be sufficient to make the risk to

* We have the well-known instance of Buonaparte escaping from Toulon under the very nose of Nelson.

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the enemy very considerable. We know also that, at one of the earlier bombardments of Port Arthur by the Japanese fleet, on March 10th, 1904, when one of their battleships exposed itself for a few minutes to the fire of one of the Russian forts, at a range of 12,000 yards, so hot was the fire that the vessel in question rapidly sought the shelter of the cliffs from which she had emerged; the next shot would probably have sunk her. Their ships preferred even to keep outside 20,000 yards.

Thus we know very distinctly how greatly ships fear modern heavy guns mounted on fixed defences. The one thing Admiral Togo learnt to be careful about was to keep his ships outside the range of the guns of Port Arthur. Has, however, full justice yet been done to the economic value of the range and accuracy of such guns? Have we yet correctly gauged the full importance of the great fear that modern battleships have of them; and the consequently great part they may yet have to play in Coast Defence? Again, in the rapid fire and accuracy of heavy field guns and of machine guns, have we not other formidable weapons to be placed, wherever full command of view and range permit, so that the greatest advantage may be taken of their power—as can be done when firing out to sea.

Guns mounted on land possess this further enormous advantage over guns mounted on ships, that they can attack anything coming within their range without any reasonable fear of effective counter-attack or, if carefully concealed, of revealing their own position. Nor have they anything to fear either from tempests, mines, or torpedoes. It is then to the artillery that we must turn as the basis of our organisation for Coast Defence.

Let us inquire next how Naval experts themselves suggest that we on land should guard against raids or surprise disembarkations on our shores. They first lay it down as an axiom, and in this we all concur, that the men on land must be in their positions *before* the enemy's ships are sighted on the horizon. "It will be too late to get the men to their stations if we wait *until* the ships are sighted. Within an hour of that time it would be quite possible for a covering force to land. Every effort must be made to prevent a disembarkation taking place unopposed; a very small number of men properly placed, even if only behind hedges and walls, would be quite enough to make it a work of very great difficulty and danger." * The enemy, we are further told, will attempt to land in some part of the coast *clear of the fixed defences.*

It is manifest from this line of argument that to successfully counteract the conditions favourable to disembarkation, either we must in times of emergency have infantry at all times ready behind walls and hedges along the intervals between our defended ports, or

* Capt. Slade's article, *R.E. Journal*, April, 1906.

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we must extend our lines of batteries on the flanks of those ports until they meet, the intervals between ports being thus guarded by land batteries. Seeing the range, accuracy, and rapidity of modern heavy guns, field artillery, machine guns, and magazine rifles, is not the latter the better alternative, since the former course is practically impossible? That is the question I have to ask.

In endeavouring to reply fully I will first observe that it follows from what has gone before that,

(1). It is the duty of the Navy, as our 1st Line, if strategically possible, to prevent altogether both raids and invasion.

(2). It is the duty of the Coast Defence, if a raid gets past the Navy, to prevent a successful disembarkation.

The question is how is this latter duty to be most efficiently and economically performed?

We are in search of a system of Coast Defence particularly suited to the characteristics of our native land, which are very marked and peculiar. We wish to cease mere imitation and to commence artistic construction. England, as distinguished from most foreign countries, whose military affairs we have sometimes been too prone merely to imitate, may be described as being a small island with many ports and full of large towns. The result is that those towns are very close together, not only inland but along our shores, and more especially along our southern coast where large cities and commercial ports are separated by very small intervals.

From the Nore to the Lizard may be taken as 400 miles; and along this space there exist already seven more or less defended ports, so that the average distance between them is but 57 miles or thereabouts. As the range of heavy guns is 15,000 yards it now suffices to place heavy gun batteries 10 miles apart; so that only 5 such batteries would be required to each average interval. I am aware that the length and danger of the intervals varies considerably, that between Portland and Plymouth being the greatest, and that from Dover to Newhaven the most exposed; but I estimate, as I shall show, that 36 heavy (9·2″) batteries would suffice. These, of course, would not be placed at uniform intervals of 10 miles, but would be grouped, being nearer or farther apart according to the dangers of the coast. Similarly each heavy battery would consist of say 3, 2, or even 1 gun, according to circumstances. Attached to each of these heavy batteries, which by reason of the great size of their guns must be fixed, there would be movable batteries of 5″ or 4″ guns, 15 prs., and machine guns in plenty.* All men, more especially those in reserve, would further be armed with magazine rifles.

* Each 5″ heavy battery could defend 10 miles against a landing from transports by day.

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Such is the system now presented for consideration, particularly by those whose homes and property are situated on our coasts. With an organisation based on this method every important anchorage would be defended and watched, at, as I shall presently show, a minimum cost and with maximum efficiency, no surprise raid or disembarkation being possible. Every range would be marked and known, and lit up, and emplacements prepared for movable armament and electric lights in the intervals. Thus, even if a temporary landing were effected in a fog or by night, destruction would await the raiders on the weather clearing.

Under the old system the plan was to surround our naval bases by a ring of forts. This plan has been abandoned; but there is still a tendency to deploy considerable garrisons round our defended ports and employ our heavy movable batteries in their immediate neighbourhood for what is called defence against land attacks. Having regard to the characteristics of our island fortress this appears to me a mistake in tactics. *A land attack should be made impossible.* For us the place to meet the enemy, the place to take him at a disadvantage, is during disembarkation in the curtains between our defended ports. If we once allow him to land and to march to the attack of our defended ports on their land side, we forfeit forthwith all the advantage of long range artillery fire. Inland, in our undulating country, it is impossible for us to get this, whilst we at the same time offer the enemy on land all the advantages of cover which it is impossible for him to get at sea. Heavy guns, on the sea coast, are so placed as to get the greatest possible advantages which they can confer. They have there the greatest possible field alike of fire and of view; whilst, properly supported by smaller pieces of artillery, machine guns, electric lights, and rifles, they are practically immune from attack by sea. I may be wrong, but it does not seem to me that there can be any doubt upon this point; *the enemy must not be permitted to land, be he raider or invader.*

Occasional heavy fixed batteries, with movable artillery, machine guns, etc., to move up rapidly between them, is the suggestion. To see how the scheme works out in detail requires reference to the map and a knowledge of our coast. But, even omitting the fixed batteries, and merely dividing our coast into sections, here at any rate is a principle and a definite system of Coast Defence based on it; namely absolutely to defy and defeat raids before or during disembarkation, mainly by artillery skilfully placed in selected positions on our coast—rather than to permit the enemy to land, and then suffer a siege or land attack, affording him all the advantages of cover of which the sea deprives him. The strength and efficiency of such a scheme it seems in every way desirable to consider,—or find a better.

I will now discuss the economy of the scheme, so important in time of peace, bearing in mind that every fully-fledged battleship

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costs now nearly two million pounds sterling. The data, which I have so far been able to get, may not be altogether reliable, so are subject to modification, but I have tried to err on the side of excessive cost. As already stated I take the Southern Coast, from the Nore to the Lizard, as an example, and the number of heavy batteries there required I estimate at 36. Taking into consideration such places as the Goodwin Sands and other areas of difficult navigation, this is no doubt considerably in excess of actual necessity. I place the batteries roughly as under :—

Sheerness to Dover	4
Dover to Newhaven	7
Newhaven to Selsea Bill	5
Swanage to Portland	3
Portland to Plymouth	11*
Plymouth to Falmouth	4
Falmouth to Lizard	2
Total heavy batteries of one to three 9·2″ guns each ...	36

Assuming that there is allotted to each heavy fixed battery station, to fill the average interval of 10 miles between it and the next,

1 battery of four 5″ or 4″ guns,
2 batteries of four 15-pr. do.,
4 batteries of six machine do.,

then the total cost will be :—

36 9·2″	batteries @ £60,000 ...	...	£2,160,000
36 5″ (or 4″)	do. @ £12,000 ...	...	432,000
72 15-pr.	do. @ £6,000 ...	...	432,000
144 machine	do. @ £2,000 ...	...	288,000
			3,312,000
Alternative emplacements, hut barracks, and electric lights			688,000
	Total	...	£4,000,000

Thus, to tie costly battleships to our shores, or in any way hold them directly responsible for the defence of our coasts against raids, is, it seems, a costly extravagance ; since for a prime cost of £4,000,000, *i.e.* little more than the cost of two such ships, our southern coasts, the commerce of which is increasing so rapidly, might be made secure. The Navy might then be set free from all anxiety concerning them, to perform its own functions with its

* Eight would probably suffice, or even six.

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strategy undistracted by thoughts of our coasts. Would not such a system conduce materially to the peace of mind of our inhabitants? The Navy tell us they cannot guarantee to prevent raids—they may be miles away; and the recent surprise raid of the Japanese at Chemulpo, before the declaration of war had reached that place, is for ever held up to us as a warning. We have in addition the recent American experience and the anxiety in the United States during the Spanish-American War. Finally, we have the experience of our own history a century ago; though long peace and a very poor acquaintance with the past have lulled the present inhabitants of our coasts into forgetfulness or ignorance of the events of those days.

The history of that period, however, and the whole sequence of events bearing upon the question of defence in the early years of last century, including the first formation of Volunteer corps, warn us plainly of the inevitable agitation and alarm which arise in times of national danger. Thus, referring to the difficulties that Lord St. Vincent and Nelson had to deal with in this respect, Capt. Mahan tells us that "The trouble for them undoubtedly was that which overloads, and so nullifies, all schemes for coast defence resting upon popular outcry, which demands outward and visible protection for every point, and assurance that people at war shall be guarded." With regard, however, to this dictum, given some years ago, we have to consider the fact that history has also shown repeatedly that Governments cannot resist this cry. The Chemulpo incident further shows that to-day there is more call than ever for vigilance. And finally, is it not the part of strategy (as Capt. Slade suggests) to consider the inevitable effect of such outcries? For convenience, therefore, I will briefly give the sequence of events as they occurred a century ago.

1801.—Nelson placed in command of a "Squadron of Particular Service" for the defence of the coast of England against invasion. "His presence in charge of the dispositions for defence only could quiet the public mind." He organises a flotilla and proposes Stationary Floating Batteries. Yet disdains mere defensive measures, and is more inclined "to keep the enemy as far from our coasts as possible and be able to attack them the moment they come out."*

1802 to 1805.—Fortifications, Martello towers, the Hythe military canal taken in hand by Pitt to allay the public mind. The Volunteers first formed and compulsory Militia Ballot enforced.

1805.—Nelson and his fleet thousands of miles away from our coasts in pursuit of the French.

* Mahan's *Life of Nelson.*

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Whatever might have been correct strategy, our Government at that time was compelled to defend our coasts at extravagant cost. This may not have been wise or good strategy then; but would it not be both good tactics and politic to-day to take full advantage of the economic and defensive power of modern weapons which did not before exist.

Yet, whatever be our system of defence, it is neither guns nor ships nor machines of any sort which in the end decide the fate of nations; it is *the training of the men.* It must never be our tendency to place too much faith merely in building ships or in mounting guns. Ships must be handled with skill, and guns must be fired with accuracy, and the men themselves must be ably commanded. Russia, with all her vast resources, had to succumb to Japan, because the Japanese were better trained and better prepared, and had in every way better calculated the risks they intended to incur. We ourselves, only very recently, barely escaped succumbing to a very small power indeed, because we had under-calculated our difficulties. Should we not then endeavour to calculate with care, and be prepared to face the dangers to which our coasts would now be exposed in time of war under modern conditions.

How keenly at times Nelson's experience of a hundred years ago reminds us to-day that the old state of affairs is still existing, since, to all appearances, Englishmen are still reluctant to obey the demands of the times on their service. Capt. Mahan tells us that when, a century ago, Nelson "issued a proclamation to the Fencibles assuring them that the French undoubtedly intended an invasion, that their services were absolutely required at once on board the defence ships," only 385 out of 2,600 volunteered. Is Nelson's remark surprising that "They are no more willing to give up their occupations than their superiors."

It is strange how closely this remark coincides with the experience which Washington had recorded not many years earlier. Indeed, few things in history seem to me more sad and solemn than the picture of himself, drawn by the great American patriot, as he sat down, in the depth of the night, to indite to Congress a general impeachment of the principle of mere volunteering under the influence of patriotism as a basis for military service. "From the hours allotted to sleep," he says, "I will borrow a few moments to convey my thoughts on sundry important matters to Congress. I shall give them with that sincerity which ought to characterise a man of candour, and with the freedom which may be used in giving useful information, without incurring the imputation of presumption."* After a few preliminary remarks he thus expatiates on patriotism as a hopelessly broken reed on which to lean. "When men are irritated and their

* From a semi-official history published in 1805.

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passions inflamed, they fly hastily and cheerfully to arms; * but after the first emotions are over, to expect, among such people as form the bulk of the army, that they are influenced by any other principles than those of interest, is to look for what never did and, I fear, never will happen; the Congress will deceive themselves, therefore, if they expect it. A soldier, reasoned with upon the goodness of the cause he is engaged in, and the inestimable rights he is contending for, hears you with patience, and acknowledges the truth of your observations, but adds that it is of no more consequence to him than to others." Such was the opinion and experience of one of the finest of soldiers after several years of trial of militia and volunteer systems; and our own experience toward the end of the Boer War was similar, when it became difficult to raise volunteers even with pay at 5s. a day. It is training under the law of the land which makes soldiers.

My desire is to inculcate the lesson that the defence of our coasts is the defence of our own homes, and that it takes but a little sacrifice of time to learn to manipulate a gun. Probably two months a year would suffice, and it would be no great hardship for every youth along our coasts to be made to serve two months every year for three years. In time of war, all those not required for the guns would then be available as reserves and be armed with rifles.

The number of men actually required to man the guns of my estimate may thus be roughly calculated as under :—

Heavy Guns	... ...	... 2 × 36 × 50 = 3,600
4·7″ ,,	... ...	... 4 × 36 × 30 = 4,320
15-pr. ,,	... ...	... 4 × 72 × 30 = 8,640
Machine ,,	... ...	... 6 × 144 × 10 = 8,640
	Total	25,200

Assuming that this number of men were paid 3s. a day, to cover everything, for a training of 60 days a year, the cost would be £226,800 per annum; and if one fresh contingent joined each year and each contingent served for three years, the total annual cost would be £680,400, less waste. This sum could be reduced to nearly half by requiring only 30 days training in the second and third year, except for experts such as gunlayers, besides occasional surprise mobilisations. After three years with the Colours each contingent would be liable,

* "They are ringing the bells now, they will be wringing their hands soon," said Walpole when the City bells pealed on the declaration of war with Spain.

"The press teamed with bombastic articles * * * the need for discipline and training * * was scornfully repudiated. Ignorance of war and contempt for the lessons of history were to cost the nation dear." —Henderson's *Stonewall Jackson.*

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during a further term of six years, to be called up as reserves in case of war.

In this estimate the gun detachments have purposely been taken at excessive strength, not only to allow for casualties, but to be sure of not under-estimating. A certain number of men of the garrison would be required as escort, for defence of fixed emplacements with rifles against small boat attacks at night, and as signallers, sentries, and so forth, over and above cook-mates and fatigues. Similarly I have shown the cost of three contingents for two reasons :—(1) assuming the men to be Volunteers, only a proportion would report themselves for duty, or remain out for any length of time ; they would have to come out in reliefs. (2) if, on the other hand, they were raised by compulsion, all men would have to be trained ; although in time of war only a certain number need be called up, yet in all probability three contingents would be desirable, allowing two of these to act as riflemen or infantry in the intervals between the fixed batteries and as guards, etc.

The estimate is not intended to be complete, but only to enable a rough idea of cost to be arrived at and to show how very cheap such a system would be ; each reader must draw his own deductions and complete the estimate. But the figures suffice to show at how small a cost our coasts might be made practically secure against raids. It seems certain that, otherwise, in case of national alarm, agitation for Coast Defence must again occur with its inevitable tendency to hamper the freedom of action of our Navy.

The carrying trade is gravitating every day more to our southern shores, and foreign ships are becoming daily better acquainted with them. Thus the interests to be protected grow greater, and the dangers to which we are exposed grow in proportion. Even granting commerce tends towards peace, the danger of war, in case we slumber, is increased. Impenetrable China is awakening from her dream ! Shall we in turn doze, fancying ourselves safe behind our wall of iron ships ?

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*THE PROTECTION OF BUILDINGS FROM LIGHTNING.**

By ALFRED HANDS, F.R. MET. S.

THE privilege that has been accorded me of addressing you on the protection of buildings from lightning is particularly appreciated because I believe it is the first time an independent expert has had the honour of addressing your Corps on the subject. In 1861 Sir Wm. Snow Harris arranged to deliver a course of lectures at Chatham; but a painful malady, that resulted in almost total blindness, prevented his delivering them. This was a loss, not alone to the Royal Engineers, but to the whole world, for Snow Harris was a master of the subject. He owed his grasp of it to the fact that he was not only an experimenter but had investigated a great number of cases in which damage had been caused by lightning, and he drew his deductions largely from the experiments that nature had carried out. It is only because I, too, have devoted considerable time to inspecting cases of lightning damage, and especially those in which lightning conductors have failed, that I have ventured to bring the subject before you. In the course of this investigation I have come across many cases that, I think, throw considerable light on this intricate subject; and I shall try and bring some of these before you, to explain the conclusions at which I have arrived and the methods I have found advisable to adopt in protecting buildings.

FREQUENCY OF DAMAGE BY LIGHTNING.

It is scarcely necessary to insist on the fact that a very great amount of damage is caused by lightning in this country every year; but it may be of interest to call your attention to a chart of England and Wales on which I have for some years been marking the positions and nature of objects damaged by lightning by differently coloured spots. I have collected particulars of such occurrences for the past 17 years, and, when all are located, I hope it will give some indication as to the relative frequency of lightning strokes on different soils. At present I have only completed a little over 9 years; but even at this stage two facts are shown that are contrary to popular opinion.

* Lecture delivered at the School of Military Engineering, Chatham, on December 6, 1906. The "Experiments" were all explained by realistic models.

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Firstly, damage occurs more frequently in towns and densely populated districts than in the open country; with a few exceptions, wherever there is a collection of spots a town is situated, and in this way nearly all towns of importance, and especially the large manufacturing centres, are indicated. Secondly, the cases also occur more often along valleys and on comparatively low lands than on the heights, doubtless because storms are liable to follow the courses of valleys. I may mention that there are on this chart 5,767 spots;—representing 2,485 buildings (of which 148 are churches); 929 trees; 196 ricks and stacks; 172 persons killed and 728 injured; 1,004 cases in which animals were killed, varying from single ones to as many as 45 in a flock; and 253 objects not covered by any of the other classes.

THE LIGHTNING RESEARCH COMMITTEE'S REPORT.

It is impossible to approach the subject of protection from lightning without referring to the present aspect of the matter in the popular mind and the causes that have led to it. There is at the present moment a great deal of scepticism as to the utility of lightning conductors; and this has been caused, directly and indirectly, by the recent so-called Lightning Research Committee and its Report published last year. Time will not permit me to point out all the peculiarities of this Report; however, I may say that it is not only so contradictory that one cannot say definitely what is or is not recommended, but it contains grave mis-statements that would lead the public to suppose that science had been seriously at fault and that, what I may call, orthodox methods of protection are useless.

It states that, out of 115 reports of disasters which occurred during the three years the Committee was collecting particulars, 40 related to buildings fitted with lightning conductors. These figures were apparently communicated to the press before the Report was published; and they naturally led to comments that, if one out of every three buildings damaged by lightning had conductors, then conductors must not only be useless but might even be a source of added danger. I have since challenged these figures and obtained a public admission that they are incorrect. As a matter of fact, during those three years, nearly 1,200 buildings were damaged by lightning in this country, and of these only 24 had conductors.

The recommendations of this Committee are of no more value than its statistics. They are avowedly founded on reports by observers, most of whom knew nothing of the subject and were incompetent to form a correct estimate of what they saw; and the reports were in many cases remarkable for their inaccuracy. It is curious how reports often distort facts into extraordinary occurrences that one would think a little scientific knowledge would show to be contrary to the laws of nature.

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In explaining some of the cases, I will give the published descriptions as a contrast and to show how little such reports can be relied upon to govern our views of the matter. I may explain that in the diagrams I have tried to illustrate the structures in the way they appear to me ; that is, I have given a sort of Röntgen ray view, with the idea of relative resistance conveyed by shade. Thus, the air, resisting most, is shown black ; buildings, resisting less well than air, are shown grey ; and metals, resisting very little, are shown white. The ground is shown grey near the surface but white below to indicate the conducting stratum that may be regarded as good "earth."

THE SCIENCE OF LIGHTNING PROTECTION.

The science of protection from lightning is not an easy one, but why is it difficult ? We know that, in accordance with electrical law, a discharge will take the path of low resistance in preference to that with a high one. If we took a piece of stone and placed a line of metal along it from end to end, except for a break in the centre, and then subjected it to a discharge from an electrical machine ; or, if we had a real obelisk composed only of the same material, and fitted it with metal in the same way, and it was struck by lightning—the spark would pass along the metal. If damage occurred it would only be at the gap ; the discharge would not go through the masonry in preference to the metal. The experiment might be repeated any number of times, either with the model in the laboratory or with a real obelisk and nature, and the result would be the same.

Examples of Damage by Lightning.

(1). A Sussex church that was struck in 1891 illustrates the obelisk I have been explaining. Someone was looking at the clock at the time, and declared he saw the flash strike it obliquely in a certain direction. We will let our spark strike the vane and watch the effect.

(*Experiment.*—Spark strikes vane, and another spark appears between clock and nave roof).

The explanation is that the bolt rod of the vane, instead of extending down a few feet only as usual, was carried down the whole length of the spire, about 40 or 50 ft., and ended just above the works of the clock ; a piece of copper wire, passing from near the lower end of the bolt rod to the clock works, formed a connecting link between the two. The course of the discharge, therefore, was from the vane, down the bolt rod, and through the copper wire (which was fused) to the clock works and face, this part of the course being invisible, not only because it was within an enclosed space, but because it formed a conducting system. The discharge then passed, as a luminous one through the masonry of the tower, shattering it, and finally to earth by the lead flashing and rain pipe. What

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the observer saw was the bright light here and he imagined the rest.

I may add that my description is not entirely hypothesis. In all the cases I am showing there were the usual clues that one picks up as one goes along—clues which might appear insignificant individually, but which, taken in conjunction with one another, form convincing chains of evidence.

Reverting to the obelisk, if we completed the line of metal so as to form a continuous conductor, the obelisk would be protected. Electrically bad joints and a bad earth connection would not force the discharge to go through the masonry. Bad joints would only cause injury to the conductor; and a bad "earth" would probably result in a barrow load or so of soil being blown up. The concussion due to the explosive force that blew up the ground might possibly crack the masonry slightly on the surface, but this would be the worst that would happen.

Rival Conductors as Alternative Paths.

But if the obelisk, in place of being solid masonry, was built hollow, with stone steps in the interior, and with a gas pipe carried up inside to afford light at intervals, the problem would be an entirely different one. There would be a rival conductor in the interior—an alternative path of metal—with a perfect earth connection because the ramifications of the gas main underground would afford only a nominal resistance to earth. Therefore, if the intended conductor had a high resistance, the bulk of the discharge would spark through the wall and pass to earth by the gas system. The earth resistance of a gas main is a mere fraction of an ohm, and it is practically impossible to get an appreciably lower one for the conductor; so, even if we gave the latter what is called a "good earth," there would still be the rival in the interior and the danger of division of the discharge between the two paths of metal, for a thickness of a foot or two of masonry is poor insulation to withstand the voltage of a lightning flash.

For efficiency it would not only be necessary to have a conductor with a minimum resistance, but it should be fixed on the opposite side of the structure to the gas pipe, so that there would be a sufficiently thick buffer of insulating material between them and the discharge would not be able to spark through. I consider the safe distance for masonry or brickwork to be a little over 4 ft.; less than this is risky, because the question of sparking through the wall would depend on the relative thickness of the masonry and the power of the flash.

(2). I will reproduce a case of alternative path that occurred in North London (*Fig.* 1). The case was described as follows in a list of reports issued by the Lightning Research Committee and exhibited at Earl's Court Exhibition in 1903:—"February 26, 1901. London: German Lutheran Church, Ritson Road, Dalston. Flash passed through rose window at north end, leaving stone tracery intact but

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destroying the organ immediately behind it and setting fire to the timbers of organ loft."

The evidence that appeared to warrant this peculiar report was the fact that the spire was uninjured; on the other hand, the north window was destroyed, indicating apparently that lightning had passed through it, and a fire was caused at this end of the nave that did, I believe, about £2,000 damage. According to this, lightning ignored the tall spire, about 170 ft. in height, that had a lightning conductor upon it; ignored even the north gable, close to which it was supposed to have passed, that had lead flashing down both sides, which, in conjunction with the rain gutters and down pipes, formed lines of conducting material almost to the ground—it ignored these, because it preferred a path of infinitely greater resistance through the air to curl in through a window, about 20 or 30 ft. from the ground, being attracted, I suppose by some organ pipes! Yet it was sufficiently satisfactory for the Research Committee to accept and print in its records.

We will reproduce the case, letting the discharge do the orthodox thing and strike the vane on the spire.

(*Experiment.*—Spark strikes vane and fire occurs at meter and spreads up staircase to organ loft).

The case is set out in diagrammatic form in the illustration, and it will perhaps make my explanation more clear. Attached to the bolt rod of the vane was a lightning conductor carried down inside the spire and out through one of the windows, where it descended the tower and ended in a rain down pipe in this corner, so that there was practically no earth connection. The down pipe was in contact with the lead flashing that passed up round the back of the tower to the other side, where there was another down pipe. Near this was a gas lamp, set to light the passage; the gas pipe passed through the wall to the interior and along to the meter at the north end. There were, therefore, two lines of metal; one, the lightning conductor continued by the rain pipe with a bad "earth"; the other, the conductor continued by the lead flashing, rain pipe, and gas pipe, to the perfect "earth" afforded by the gas main; and lightning took the path of least resistance.

That a fire was caused at the meter, owing possibly to a bad joint, but more probably to crossed inlet and outlet pipes, was a natural consequence; and it was also a natural consequence, I think, that the fire, having started in a cupboard under some wooden stairs, should have spread up the staircase to the organ loft, burnt the organ, and melted the leaded lights of the window.

Effect of Abrupt Bends in Conductors.

We have heard a great deal lately about abrupt bends in a conductor causing a discharge to side-flash to neighbouring metals. This opinion has arisen in a rather curious way. Sir Oliver Lodge has written a work on lightning conductors that is a valuable contribution to the subject from a theoretical point of view, though his

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practical deductions are, I consider, unsound and not warranted. In one part of this book, he says that lightning has no time to go round; it will jump across in preference, which, in a certain sense might appear correct. In another place he says that self-induction causes side-flash, which statement, taken by itself, appears true, since we know that by reducing self-induction we can decrease the length of the side-flash. Certain electricians appear to have married one statement to the other; and the issue of this morganatic union is the statement that abrupt bends increase self-induction and so cause side-flash. So much has this been asserted, that even many electricians are convinced it is true although it is contrary to electrical law. A straight wire has a certain amount of self-induction; twist it into a spiral and this is increased enormously; but zigzag it backwards and forwards, giving it in fact a number of extremely abrupt bends, and self-deduction and consequent side-flash are reduced to a minimum.

(3). I want to call your attention to the course followed in this case, the discharge going by nine abrupt bends to get to a good earth in preference to a straight course to a bad one. While I have the model here I will show you a variation of the last experiment. I cut away the lead flashing that connects one side of the tower with the other, so that this alternative path is no longer open. We let the spark strike the vane as before.

(*Experiment.*—Spark strikes vane, and fire is again caused at the meter, with the same result, because there is now another alternative path open).

When making this model I placed a line of lead foil over the south gable to represent lead flashing, although, if I remember rightly, there was none in the original. Its being here did not affect the first experiment because I left a break at the back that was afterwards made up with a piece of wire. It now enables me to show you what a roundabout course a discharge will travel, and how necessary it is to guard against alternative paths no matter how circuitous. The course is now down the conductor; along the rain gutter southward; up the roof and down to the east side; along the rain gutter northward; up again over the roof to the west side; along the rain gutter southward; down the rain pipe; back to the gas lamp; and on by the combination as before.

It might be asked—"How is it possible to protect this building, since, however perfect the lightning conductor in that corner, there is always open the alternative path to an earth connection at least as perfect as that of the conductor?" If we followed the Lightning Research Committee's recommendation and put two, or even a dozen, conductors on the spire, the same thing would still happen. Protection is a much more simple matter than this; run the conductor down the south-west corner, and it would then be sufficiently far removed from these dangerous complications.

The obelisk I have been explaining is the simplest possible case.

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If all buildings were as simple as this, protection from lightning would be so ridiculously easy that a Council schoolboy could, by means of a few set rules, learn to protect them efficiently. The problem one is sometimes confronted with is more like this:—Metal cowls on chimneys; lead-covered ridges and flashings; metal girders, stoves, and casements; rain water gutters and pipes, gas and water service pipes, etc.,—altogether affording a problem that would require very careful studying.

Before going further into the matter I will show you a few cases of so-called lightning conductor failure in diagrammatic form.* I regret that time did not allow of my making models so as to reproduce these experimentally also. Examples of Lightning Conductor Failure.

(4). On the tower of Stradbroke Church, Suffolk, struck about 5 years ago, a lightning conductor was fixed to the corner turret, but not connected to the vane; therefore, if the turret had been struck, the masonry between the vane rod and the conductor would have suffered. The point struck, however, was the flagstaff at the opposite corner, that had no conductor. The course of the discharge, after shattering the flagstaff, was along the lead roofing, up to the metal hinges of the turret door, and then through the masonry to the conductor, by which it passed to earth without further damage, although the resistance to earth was about 900 ohms; there was no possible alternative path in this case.

The system I recommended comprised a main conductor from the flagstaff, with branches from the vane and the two other pinnacles, the whole being connected to the lead roof.

(5). *Fig.* 2 shows Needwood Church, Staffordshire, struck about 14 years ago. The system comprised a main conductor from one pinnacle to an earth with a copper plate, 3 ft. × 3 ft. × $\frac{1}{8}$ in., bedded in clay soil, the resistance being about 12 ohms, and branches from the other three pinnacles. A very bad bend was formed by the conductor being carried down to the lead roof and then up again over the parapet wall. The discharge did not spark through the parapet, but the conductor was ripped loose there. I have on several occasions noticed what I take to be a tendency for a conductor to straighten itself when struck by lightning; and, if the fastenings are not very secure, a bad bend like this leads to the conductor being torn loose.

On the ground floor, inside the nave, was matting the ends of which were bound with lead about equal to a 1-inch pipe flattened out. There were three lengths of lead binding, the first one being just behind the conductor, and the second just above a large metal stove that rested on a damp floor in a vault. This combination formed an alternative path; and part of the discharge sparked from

* Owing to financial reasons only a few of the diagrams have been reproduced.—EDR.

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the conductor through the wall to the first lead binding, on to the next length, and through the floor to the stove. The discharge was undoubtedly exceptionally severe in this case.

The course of the conductor was altered so as to do away with the up-and-down bend, and the lead binding was ordered to be removed.

(6). In Kea Church, Cornwall, struck about six years ago, the spire was entirely copper covered, but a conductor was carried over it from the vane to the ground. I was told there was an earth plate, but did not test it, and do not know the resistance; as the church is on a hillside the resistance would probably be rather high. It was reported that lightning had struck the roof of the nave close to the spire, because this was the only place damaged, but I found that the vane had been struck. The discharge had divided between the conductor and a rain down pipe in the corner, both being connected at the top by the metal roof, and both having practically the same earth connection because a piece of copper wire, put up to support some creepers, was stretched across from one to the other a few feet above the ground. The portion of the discharge that passed down the rain pipe divided again by sparking through the parapet wall to the lead flashing (down the roof of the nave), which, with the rain gutter and down pipe by the porch, formed another line of metal to the ground.

I believe the authorities afterwards had the rain pipes earthed with the idea of letting the electricity escape, which would only make matters worse; what was wanted was a connection of metal across the top of the parapet wall from the rain pipe to the lead flashing.

(7). *Fig.* 3 shows a very common case,—a short elevation rod fixed on a chimney, and near it a much higher mass of metal in the form of a cowl. The discharge passed through the cowl, and shattered the corner of the stack in passing to the conductor. Here the elevation rod should have been fixed on the cowl, or else a connection of metal should have been made from the cowl to the conductor.

Surging Effect of Lightning Discharges.

These cases are all comparatively simple ones. I propose showing next some results due to the surging effect of a discharge; and, as this is often overlooked and is possibly not very generally understood, I will explain it first in case anyone present has not considered the matter. Electricity—or, perhaps, I should say, the movement in the ether that causes electrical effects—has properties that correspond to inertia and momentum in matter, and in scientific terms they are called electro-magnetic-inertia and electro-kinetic-momentum. We have to remember that when a conducting system receives a discharge, it is momentarily charged because of inertia having to be overcome, and the consequent sudden rise and fall of potential does not leave outlying parts of the system at a normal level. There is an alternate rise and fall like the water in a bath that has been tipped up suddenly at one end. Although the effect is all over in a fraction of a

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second, damage might occur which, although slight in itself, might have serious results; so precautions should be taken to guard against it.

Although water is not a good analogy, it is the best I can think of to bring the action to mind. Imagine a system of canals. Suppose a main canal, open to the sea, and equivalent to a conductor with a good earth connection. To right and left suppose two branch canals, equal to branch lines of metal from the conductor, the former having only a very weak wall dividing it from a pool of water, while all the other banks are sufficiently high and strong to resist pressure due to the rise and fall of the water level. The pool represents a piece of metal near the far end of the branch conductor and not connected to it. If the level of the water in the main canal were suddenly raised enormously, there would be a rush along the canal due to the passage of the extra head of water to the sea, but the water in the branch canals would not remain at normal sea level; there would be a surging effect along them. In the left hand canal there would be no effect beyond the rise and fall of water; but with the right hand one, the dividing wall, being very weak, might be broken down. The strength of the wall represents the insulating strength—or, in other words, the distance—between the branch conductor and the adjacent metal, and would determine whether a breakdown, or spark, occurred between the two.

(8). Some 10 or 12 years ago lightning was said to have struck down inside a brick chimney on the ridge of a small corrugated iron building situated close to Happisburgh Lighthouse. It did not damage the chimney; it did not even avail itself of the large amount of conducting material afforded by the metal sheeting to get to earth; it passed down the centre of the flue and then, in some mysterious way, got to a gas pipe and caused a fire by lighting the gas! In order that you may be able to see into the interior, I have covered the model with wire gauze in place of metal sheeting, but the effect, from an electrical point of view, is the same. We will let a spark strike the lighthouse and see what happens.

(*Experiment.*—Spark strikes lighthouse and fire breaks out in small building).

In explanation I may say that the lightning conductor system in use for English lighthouses is practically that recommended by Faraday in 1843: a stout bar of half-round copper is connected to the metal-work of the lantern, and carried down inside the lighthouse, being connected to all the metals in the interior. At the bottom it passes out to an ordinary copper-plate earth connection.

In this case a pipe from the gas-making house passed underground to the lighthouse and up to the top to provide gas for the lantern, and this pipe was, of course, in connection with the lightning conductor. Another pipe, in connection with the first one, passed

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underground to provide light for a small building, which was in use at the time as men's quarters. There was, therefore, a line of metal, connected to the lightning conductor at the top of the light-house and carried along underground into the small building, but not connected to the iron framework or corrugated iron covering of the latter; there was a small gap between the pipe and the framework of the building, and here, owing to the surging effect I have described, a spark would occur, lighting the gas, as it has done in the experiment.

The cure in this case is a very simple one; connect the outer sheathing of the building to the gas pipe where it enters the structure, or (else) the gas pipe to the iron framework where it passes near to it, and no spark will occur.

Distant Effects of Lightning

We next come to effects that are by no means uncommon but have hitherto been misrepresented owing to their not having been understood; cases in which objects are struck by lightning and effects occur at some distance away. For instance, a church spire might be struck, with or without a conductor upon it, and persons in a neighbouring house, who happened to have metals in their hands at the time, might receive slight shocks that would perhaps appear severe because they were unexpected. A man walking with a gun on his shoulder near a tree when it was struck would get a shock, and say he had been struck too. Workmen handling metal tools are especially liable to these effects when near lightning-struck spots. The Vicar of St. Agnes, Scorrier, Cornwall, sent me this year an account of a storm in which there was only one flash; this struck and damaged his church, and men in a mine about 500 yards away and at a depth of 260 to 320 yards below the surface received shocks.

I regard these effects as due to a surging or wave effect, somewhat similar to what I have been describing but with the earth as the conductor between in place of a line of metal. It is often thought that when a lightning flash reaches the earth—to put it in popular language—the effect is all over; but we must bear in mind that generally, before a discharge occurs, the potential of a locality is raised—or lowered as the case may be—enormously, and this altered potential does not necessarily return to the normal again without effect. Taking a water analogy again, I would liken it to a water-spout forming on the surface of a lake and then suddenly collapsing. The effect would not be over the moment the column of water struck the surface; there would be a surging or wave effect that might loosen the banks at some distance away where they happened to be weak. So with a lightning discharge, we may imagine the sudden rise and fall of potential as setting electrical waves flying through the earth; where metals were so placed as to give rise to a difference of potential of sufficient magnitude, there the effects would be felt as shocks by persons in the position of links between

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those metals and the earth, or the effects would appear as sparks where two metals were so placed as to be just in the right way to catch these waves. This is how the matter presents itself to my mind; and I have found it explain many incidents that had appeared mysterious and that could have been foreseen under this aspect of the matter and, it appears to me, under this aspect only.

The greatest distance to which I have so far been able to trace effects of this kind has been about half a mile; but possibly, if the discharge were exceptionally severe or the conditions unusually favourable, effects might be traced even further. These cases are difficult to reproduce because of the difficulty of reproducing the exact conditions in a lecture theatre. In the experimental reproduction I must be content to have my models only a few yards apart. I have been tempted to select this case principally because, from seeing the marks where a slight fire had occurred, I was able to deduce the circumstances, and also in this case there was a witness.

(9). I was at Heathfield Station in Sussex one day when I noticed marks of burning and a combination of metals that led me to think I had accidentally come across an interesting case, and, having time to spare, I examined the buildings carefully. The railway line here is in a cutting, over which there is a road bridge. Above the platform on one side of the station is the booking office, abutting on to and level with the road. From one end of the booking office a foot-bridge, roofed with corrugated iron, leads across the line to give access to the other platform. From a gas main along the road a pipe runs into the footbridge just outside the booking office, and rises up to a gas jet not far below the roof of the footbridge. Some telegraph wires terminate in shackles on the wall of the booking office above the footbridge; and from these shackles insulated wires were carried into the booking office, passing on their way down the roof of the footbridge and within about an inch of the gas pipe, thus forming a connecting link between the iron pipe and the iron roof. The rubber covering of these wires had been ignited just by the gas pipe, and the small fire occasioned had scorched some adjoining woodwork.

I came to the conclusion that lightning had not struck the station, although enquiries elicited the fact that the fire had occurred during a thunderstorm. A signalman walking along the line towards the station said he did not see lightning strike there, although he was looking that way and saw the fire occur. I indicated two directions, in one of which I thought it probable that some object within about half a mile had been struck at the time of the occurrence; and I was told that a house, just about half a mile away and in one of the two directions I had indicated, had been struck and, it was believed, at precisely the same time.

What no doubt happened was this. When the lightning struck the house the discharge passed away in all directions; the portion going

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in the direction of the station was in due course more or less concentrated along the gas pipe leading to the station; the potential of this pipe, terminating near the roof of the footbridge, was raised, but that of the roof, which was insulated, remained normal; thus a difference of potential was created, which was sufficient to cause a spark between the two, across the gap between the pipe and the insulated wires, and this spark ignited the covering of the wires and caused the fire.

(*Experiment.*—Spark strikes house and fire occurs at railway station).

In this type of case there is no metallic connection between the buildings; the earth carries the wave or impulse. Whatever the object the discharge strikes, and whatever resistance it meets with, it must go to good earth, and the earth forms the conductor that carries the wave or impulse to the second object. All that is required at, what I may call, the receiver end is the suitable arrangement of metal to produce the difference of potential that will cause a spark. In the instance under reference it was the gas pipe passing along the road from the direction of the struck building (but not actually from that building) and the long length of corrugated iron roofing insulated from the ground on a wooden frame. The spark could have been prevented by making a proper connection between the iron roof and the gas pipe, or by placing the telegraph wires so that they should not form a partial connection.

It is not only one "earthed" and one insulated metal that would cause such a spark. Two "earthed" metals, such as a gas pipe and a water pipe entering a building from opposite directions and on opposite sides, and crossing or closely approaching one another inside the building, would be liable to cause a spark; and when they do enter from opposite sides in this manner (rather unusual) the case wants looking into very carefully.

Complications liable to cause Failure.

The cases I have described are ones that have actually occurred. It may be said, it is easy enough to see these things after the events; what we require to do is to see them before they occur. So I will show you a few complications I have had to deal with that had not been struck by lightning.

(10). *Fig.* 4 shows one end of the Bristol Corporation Granary. This had a conductor system in perfect order. But a telephone wire had been run to a shackle close to one of the conductors, and thence on to the instrument in a small wood-lined building used as offices, where it passed across a soft metal gas pipe. Had the granary been struck, a part of the discharge would have been led by this alternative path to the gas pipe, fusing a hole in it and causing a fire; so I ordered the telephone wire to be moved well away from the conductor.

(11). *Fig.* 5 shows part of a mansion in Sussex. A conductor had been fixed from the vane on the tower and well earthed, but afterwards metal rods were run from the vane to work an indicating dial in the

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hall. On the basement floor, below the dial, was an iron door, and running near this, almost in contact with the door, was a water supply pipe. The distance from the dial to the door would, under ordinary circumstances, have been too far for part of the discharge to break through; but, had anyone been standing looking at the dial at the moment the vane was struck, his body would have so far weakened the gap that a very severe, or possibly fatal, shock would have resulted. So a connection was run from the dial to the iron door, water pipe, and conductor earth.

(12). *Fig.* 6 is one of the east towers of Westminster Cathedral. The ledges were covered with lead, brick buttresses separating one piece of lead from another. Sparking would have been liable to occur from the one sheet of lead in contact with the conductor to the others; so connections were put in from one piece of lead to the next all round the tower. Inside the tower was an iron staircase, the top enclosed by a sort of wood canopy roofed with lead. Had anyone been standing at the top of the stairs at the moment the conductor was struck, his head would have been perilously near the lead; he would have formed a connecting link between the two masses of metal, and would have been liable to a rather unpleasant shock due to an induced effect. So I had a connection made from the lead to the handrail of the staircase and on to the conductor.

(13). *Fig.* 7 is the Lady Chapel at the east end of Gloucester Cathedral. On one of my periodical visits of inspection, I found that a radiator stove had been put in, with a metal flue pipe that was carried up and in connection with the lead roof, which was, of course, connected to the conductor. The stove rested on a gas pipe; so there was an alternative path from the conductor system, consisting of the lead roof, the flue pipe, the stove, and the gas pipe that passed along the entire length of the cathedral. I recommended that the gas pipe should be diverted to the other side of the chapel.

(14). *Fig.* 8 shows rather a complicated case,—a large hall lighted by gas pendants from a supply pipe passing along under the ridge. Usually such a building would be protected by a point at each gable, with a copper tape carried along the ridge from one gable to the other and down to earth at some place between. But here a dangerous alternative path exists right under the ridge, and the conductor would require to be kept away from it. Therefore an independent conductor at each end, both perfectly earthed, would be necessary.

Chimney Shafts.

Chimney shafts often present difficulties in regard to protection. When hoop iron is built in for bond, there is a weak spot wherever the iron comes near the conductor; therefore, when the hoop irons are being laid, tail pieces should be brought out from them to be connected to the conductor when it is fixed. In such cases the danger of side flash would be near the top and bottom rather than in the centre.

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Sometimes a metal steam pipe is carried up inside a shaft. Here it is necessary to connect to the conductor at the top, and either connect at the bottom also or otherwise earth the pipe. Besides this it is necessary to trace the pipe to its source ; and make connections to any metals near it at places where damage would occur through sparking, and also possibly between one metal and another.

The various effects and complications I have described may justify me in saying that it is impossible to protect buildings from lightning by means of set rules. Each case must be studied separately, and such a system of protection applied as the complications found in the case may show to be necessary.

METHODS OF PROTECTION.

Now, how are buildings to be protected ? We may say broadly that there are three methods that might be adopted.

Firstly there is the cage system. If you have a metal box you can get no electrical effects in the interior ; and if a building could be metal plated, so as to be like a biscuit tin with the lid on, it would be quite lightning proof, but no metal must be allowed to pass into the interior without being first connected to the metal sheathing. The advantage of this method would be that no knowledge of the subject and no study of the problem involved by the complications of metal in the structure would be necessary. It is *par excellence* the novice's method. It is not even necessary to cover the building with continuous sheets of metal ; if conductors were arranged so as to form a close meshed network all over it—so as to make it resemble a birdcage—it would still form a screen against effects in the interior.

But a mere skeleton of a cage, the system that the Lightning Research Committee advocates in one part of its Report and condemns as inefficient in another, does not afford this screening effect even to a partial extent ; and the worst damage that has occurred to buildings through faultily applied conductors could still occur to one fitted with what I call the bastard cage system, if the conditions were conducive to those effects. In fact I regard a partial cage system as liable to be extra hazardous, because, while one can arrange to keep a limited number of conductors on a building clear of metals that might cause complications, it might be found impossible to arrange them in all directions in this way. If an explosives magazine was fitted with such a system, I think I could add a contrivance that would cause it to explode if lightning struck anywhere within half a mile. We have a good example of the failure of the partial cage system in the Hotel de Ville, Brussels, one of the very few buildings that have been fitted with this system ; it was struck and set on fire about 16 years ago.

For the majority of buildings the complete cage system is quite impracticable. Apart from the prohibitive cost, I have yet to find the

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architect, or even the owner, who would consent to have his building turned into a glorified aviary. Then such a luxury as a telephone service would have to be dispensed with, since to connect the wires to the cage would be impossible, and, if introduced without being connected, they might nullify the screening effect of the cage. This system may, however, be applied with advantage in protecting explosives magazines; indeed it is often a most difficult matter to protect them in any other way, because, I presume, the metals in the interior are constantly liable to change and re-arrangement. If one could be certain that the problem one studied in the first instance would be the one always in existence and not a different one set from time to time, a much more simple method could be devised.

The second method is to connect every particle of metal in and about the structure to one another and to the conductor system. Then no sparking or side-flash would occur, because there would be no gaps between metals where, owing to difference of potential, sparks could occur. This method is the one attempted by Trinity House for lighthouses, but for ordinary buildings it is impracticable also.

The third method, which I regard as the practical one, gives, I think, the maximum of efficiency with the minimum of cost; but it necessitates a profound study of the subject and very careful consideration of the buildings to be protected. First one must determine what are the parts of the building liable to be struck, and run continuous lines of metal from these to good earth connections, either as main conductors, or as mains and branches, as may be most effective; then one must consider the effect that would occur if either of those conductors was struck by lightning, and make connections across any sparking gaps, either between the conductor and other metals or between those other metals themselves, if the sparks were calculated to do harm.

There are some metals about a building that should not be brought into connection with the conductor system, and these should be carefully avoided by giving the conductor a course that is beyond sparking distance. The question as to what shall, and what shall not, be connected is the most difficult one of all to decide, and no fixed rule can be laid down; it must be decided by the problem found to be involved.

Knowledge necessary for Success in Protection.

In considering the subject of protection from lightning, I think that too much importance has hitherto been attached to the form and composition of the conductor, and too little to the fact that its efficiency depends very little on what it is but almost entirely on the way in which it is applied. The subject is somewhat analogous to the work of a medical practitioner, who has to consider the symptoms and characteristics of his patient, and prescribes the remedies that his

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diagnosis of the case suggests ; the result will depend on the ability of the doctor and the correctness of his views. Although the case that the lightning protection expert has to study is not one of existing disease, it is one where the possibility of bad results is before him ; he has to consider the case on its merits, to determine all the effects that might occur, and to arrange his preventive devices in the way that he considers will be successful ; he has, in fact, to diagnose the case, and the result will depend on the correctness of his diagnosis.

None of us can lay claim to infallibility, and anyone might make a mistake or fail to notice some factor that might have an important bearing on the matter ; but the fact remains that the possession of knowledge, experience, and ability to discriminate as to the importance of details should enable a man to protect a building effectively, while absence of these would probably result in failure. At all events, it is in this direction, I think, that we should strive to improve our methods, and not in trying to devise theoretically perfect, but practically impossible, mechanical ones, the only advantage of which would be to save the trouble of having to study the subject.

Relative Values of Copper and Iron as Conductors.

I have devoted the time at my disposal to the points I regard as of paramount importance, but you would probably consider my remarks incomplete if I did not refer to the relative value of copper and iron for conductors.

So far as regards conductivity and dissipation of energy, the matter is, I consider, of such trifling importance that it sinks into insignificance in comparison with considerations of durability. A conductor is expected to last a long time, and iron, even if galvanized, is very perishable ; so we are left with copper as the alternative of these two metals. As regards the advantage of iron dissipating the energy of a discharge, this has been demonstrated experimentally and such work is often of very great value ; but there are cases where it is necessary to take proportion into account. I might show you that by hanging a sheet of tissue paper loosely in front of a popgun I could impede the velocity of the cork ; but, if I suggested the advisability of hanging sheets of tissue paper before men exposed to rifle fire, you would probably think my friends ought to put me under restraint. The experiments that show the superiority of iron are, I think, almost on a par with this. They show that a thin iron wire about a hundred feet long has a decided advantage in dissipating the energy of a six-inch spark ; but if you were to repeat the experiments with a conducting wire about one-sixteenth of an inch long and a six-inch spark—which would be about proportional to a lightning conductor a hundred feet long being struck by a lightning flash half a mile in length—you would see what I mean by saying that, in my opinion, the matter is of trifling importance.

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CONCLUSION.

There are, I presume, many present who are taking up the subject of protection from lightning as a serious study, and to those I would say—Do not think it is a dull one, merely because I may have failed to put it attractively. You will find that the deeper you go into it the greater the interest grows. New problems and fresh complications are constantly being met with and the field is very far from being exhausted; there is room for further investigation. And do not be discouraged because you meet with or hear of cases that appear, at first sight, inexplicable; there can be no such things as vagaries or freaks of lightning. I have devoted considerable time to investigating so-called vagaries and never yet found one that, on being thoroughly probed into, did not prove to be consistent and in accordance with our knowledge of the subject. There are laws governing all natural phenomena, and lightning, like every other force in nature, must be amenable to law. We do not yet know all those laws; but they are gradually being revealed, and, where we do not understand them, we should try and clear up the mystery and not dismiss the matter by saying that in one respect nature is erratic.

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MEMOIR.

Colonel Charles John Smith, late R.E.

On the 4th January, 1907, there died at his residence at Bideford, Devon, Colonel Charles John Smith, Royal (Madras) Engineers, retired, in his 71st year.

Born on 11th July, 1836, his early life was spent at Bury St. Edmunds, where his father was for many years a well-known medical practitioner. He was the eldest son of a large family, and was educated at King Edward VI. School in the town.

He joined the Honourable East India Company's Military Seminary at Addiscombe in February, 1854, received his commission in the Company's Engineers on the 7th December, 1855, joined the Royal Engineers at Chatham in February, 1856, and, having been posted to the Madras Engineers, arrived in Madras on the 26th December, 1857.

On arrival in India he was posted to the Public Works Department, and was employed on important irrigation works in the Nellore, Tanjore, and Kistna Districts, and on special investigation, until 1870; and distinguished himself by his energy and activity and mastery of this branch of his profession.

In 1870 he was transferred to the Railway Branch of the P.W. Department as Deputy Consulting Engineer for Railways, and remained in this Branch until the end of his service in 1892, rising to be Head of the Department as Consulting Engineer and Secretary to Government Railway Branch, in 1883: higher preferment he declined, feeling that his experience of the Railway systems in Madras rendered him most useful to his own Government.

In the Railway Branch he was distinguished by his thorough knowledge of his work, his strong common sense, and his tact and ability; and he earned the respect and esteem of all those with whom he was officially brought in contact.

After leaving India he settled down at Bideford, where, although his health was not always good, he continued to do good work in connection with local public affairs.

In private life dear old C.J. (as he was called throughout the South of India) was universally beloved. He made friends wherever he went, and to very many he was a friend indeed through life. His was a deeply sympathetic nature and for those in trouble or sorrow he would spend and be spent to any extent. His life was a beautiful one because it was one of self-denial for the good of others; and his loss will be deeply mourned by his family and a very large circle of friends. He was unmarried.

H.

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TRANSCRIPT.

RAILWAYS IN WAR AND MODERN VIEWS AS TO THEIR EMPLOYMENT.*

MEANS of communication have constituted a factor of decisive importance in the wars of every epoch of the history of the world. When railways first appeared upon the scene, the attention of military men was naturally directed to their strategical possibilities, the manner of their employment, and the extent to which they could be pressed into the service of war.

As is the case with every great idea, the most divergent views at first prevailed as to the value of the new invention and its applicability to military purposes. Some authorities prophesied a complete revolution in the art of war, while others considered that railways would at most be useful for the transport of war material and would not otherwise be of assistance in military operations.

Von Pönitz, the versatile military writer of that period, published in 1842 a book entitled *The Influence of Railways on Military Operations*, which is regarded as an authority on many points even at the present day. Thus, he lays down as essential that the Military Authorities should have an unrestricted right of way over all railways on the outbreak of war, and that there should be a special officer, entrusted with the control of railway transport, on the staff of the Quartermaster-General.

Von Pönitz did not, however, consider the possibility of the strategical concentration of the forces by rail; it was not till 1850, when this country was threatened with war with Prussia, that this was put into practice.

The railways in 1850 did an amount of work which was surprising in view of the limited facilities then available,† but they did not materially expedite the strategical concentration; the troops might have reached their positions almost as quickly by road. In spite of the zeal of the railway officials, the want of a proper organization for war was severely felt; no preparations had been made beforehand, there were no transport regulations, and the whole transport scheme had to be improvised. 1850.

In spite of the experience gained in 1850 as to the shortcomings of the railways, it was ten years before our military knowledge of railways was sufficiently advanced to lay down the principles upon which the science of handling this, the mightiest of all means of locomotion, is based.

* Extracts from a lecture delivered by Lieut. Edward Zanantoni, Austrian General Staff (Railway Section), at the Austrian Railway Employés Institute, Vienna.

† In November, 1850, in 26 days, the railways conveyed 75,000 men, 8,000 horses, and 1,800 guns and wagons to the northern frontier of Austria. The maximum result, which was only once attained, was the despatch of eight trains of 120 axles in one day.

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1859. It is not surprising, therefore, that the war of 1859 found both our Government and our railways unprepared. Once more it was found unavoidable to run trains without a fixed time-table, fitting them in as necessity dictated. The natural consequences of the neglect to organize the railways in peace-time followed; trains were delayed or blocked, and stations choked with a mass of supplies which could not be forwarded.

1862. Military Railway Regulations. In 1862 the first "Regulations for the Transport of Troops by Rail" were issued. These were based on the experiences of 1850 and 1859; they were intended to constitute a complete scheme of railway transport, and to provide as far as possible for the safety of the traffic, even when the lines were worked to their full capacity.

Broadly speaking, the 1862 regulations were similar, in their principal provisions, to those in force at the present day. They laid down a transport scheme for the maximum carrying capacity of the railway; they fixed the speed of military trains at 12 to 15 miles an hour; they provided for the storage of military fittings for 10 per cent. of the covered goods wagons; and they laid down the formation of standard troop-trains for cavalry, artillery, and infantry.

As a single central authority to take charge of all military movements on a large scale by rail the Regulations created the "War Office Department of Railway Transport." To this department were subordinated various Railway Committees and Local Military Railway Committees; the latter are now replaced by the present Military Commanders of Railway Stations. Finally the Regulations created a Field Railways Department for the theatre of war.

Almost simultaneously with the 1862 regulations there appeared a book, which was then looked upon as a standard work, entitled *Railways from the Military Point of View*. The author, Capt. Panz, a staff officer in the Q.M.G.'s department, had the honour of being the first to embody the experience then gained into a logical and practical military system.

Capt. Panz laid down that all locomotives must be classified as to speed and power; that a reserve of 25 per cent. of locomotives and 15 per cent. of trucks must be allowed for repairs; that the maximum period given to railways to prepare for war was not to exceed ten days (to include re-arrangement of passenger traffic, unloading and collecting trucks, and equipping wagons for military transport); that for journeys lasting over 8 hours provision must be made for feeding the troops, and for journeys of 48 hours or more for quartering them; and finally, that all preparations must be made in peace-time. These preparations include military time-tables, train diagrams,* and tables of reference giving complete information as to station facilities and rolling stock available.

In recognition of his services, Capt. Panz (who had in the meantime been promoted Major) was appointed Chief of the "Department of Railway and Steamer Transport and Telegraphs," which was added to the War Office in 1865. This is our present Railway Division.

* *Note by Translator.*—A train diagram is a board with vertical scale of time and horizontal scale of distance, upon which the progress of each train is marked by a curve. Two curves may not intersect except at a shunting-point.

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THE WAR OF 1866.

As a result of these measures, the war of 1866 found us less at sea, as regards railway matters, than that of 1859. Although the extent of our network of railways fell lamentably short of strategical requirements, yet it must be acknowledged that both the preparation and the execution of the transport of the masses of troops were adequately carried out, and that remarkably good results were achieved. 1866.

On the 15th March, 1866, the Railway Department received orders to draw up a scheme for the simultaneous concentration of the army in Venice, in Moravia, and in Bohemia. A month later everything was in readiness.

But since on political grounds it was desired to begin by concentrating the Army of the South, the whole scheme had to be withdrawn and revised. On the 25th April the railway mobilization scheme for the Army of the South was issued; that for the Army of the North followed on the 11th May. We must remember, however, that the amount of work which then had to be done was only one-tenth of that which the Railway Division is now required to carry out every year in the same time.

The transport by rail of the Army of the South began on May 1st and was completed by May 19th; that of the Army of the North began on May 20th and was completed June 9th.*

Even finer results were achieved by the railways, more especially the Imperial Northern and the Southern, at a later period of the war, when whole armies had to be transported from one of the two theatres of war to the other.

I will mention four instances, for details of which I have to thank H.E. Field Marshal von Beck, the Chief of the General Staff.

(1). Return transport of the 10th Army Corps from Lettowitz to Vienna (Mondel's Brigade to Lundenburg).†

In spite of the difficulties of entraining at the small and cramped station of Lettowitz, in spite of the pressure of the enemy and the severity of the weather, the railway transported the whole of the 10th Army Corps, together with several thousand sick and followers, within 38 hours in 20 trains.

(2). Return transport of the 3rd A.C. and part of the Saxon A.C. from Olmütz to Vienna.‡

From 9 to 10 trains per day were run, each of 200 axles or more, and in 3½ days the whole force had reached Vienna.

Great difficulties had to be overcome, due principally to the absence of returns of strength of troops to be entrained, the want of entraining facilities at Olmütz, the crowding and hurry which prevailed at the departure station, and the encumbering of the stations with masses of stores.

* In 19 days the Southern Railway conveyed, in both directions, 180,000 men, 8,500 horses, and 900 guns and wagons in 427 trains; average (one way only) 11 trains per day. In 20 days the Imperial Northern railway, into which the other lines converge, conveyed in one direction 200,000 men, 29,000 horses, and 4,500 guns, and wagons, in 458 trains; average (one way only) 23 trains per day.

† 22,000 men, 900 horses, 200 guns and wagons.

‡ 43,000 men, 4,000 horses, 700 guns and wagons.

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Moreover the section Hradisch to Prerau was only a single line, and all trains had to stop for examination at the fortified enceinte of Olmütz.

In 1870 the transport of the Landwehr division of the German and Prussian Guard from Strassburg to Nanteuil took from the 7th to the 13th October, although the division required only 11 trains, totalling 750 wagons.

(3). Transport of the Army of the South from Verona to Vienna.

The 5th A.C.* commenced to entrain on July 9th at Verona, and was transported to Vienna in 47 trains *viâ* Innsbruck and through Bavaria, The section Bozen-Innsbruck, over the Brenner Pass, was unfinished, and had to be covered on foot by forced marches. The whole force was assembled in Vienna by July 22nd.

The remainder of the Army of the South † was railed *viâ* Görz-Marburg, Görz-Pragerhof-Ödenburg, and Villach-Marburg to Vienna and the neighbourhood. It was transported in 118 trains, and transportation completed within 14 days.

(4). Return journey of part of the Southern Army from Vienna to the Italian frontier.‡

This was accomplished with wonderful celerity and precision. Only 36 hours' notice of the move was given. Entraining began on August 2nd, and the whole move was completed within 15 days. The army was transported in 400 trains, the average number despatched daily being 26 to 27. Over the Semmering, where the trains had to be divided, as many as 80 and even 90 trains per day were run.

Lessons for the Future based on Events of 1866.

If I have devoted so much time to a description of the railway achievements of 1866, it is because I consider that the results then achieved form a standard by which we may gauge the railway performances of the present and of the future. But I am bound to point out that the rapid transfer of large bodies of troops by rail from one strategical area to another, as above described, is an operation which will only be possible during the later stages of a war. It would be rash to attempt such a scheme during mobilization, or during the concentration of the army at the theatre of war, when the capacity of the railways would be strained to the utmost in conveying men and materiel.

Whatever news of the movements of the enemy may arrive during this early period, it will be exceedingly difficult to alter dispositions once made for the initial concentration by railway of the forces. At the utmost, it will be possible to alter the stations at which the troops disentrain to other stations more advanced or more retired. Even this will give rise to serious practical difficulties, except perhaps in cases where each Army Corps has a line of rail to itself.

The events of 1866 made clear to all of us the importance of a well-arranged network of railways, and foreshadowed the increased importance which railways will play in future wars. The attention of all military nations was directed to the strategical possibilities of railways, and much attention was devoted to working out in peace-time the most complete plans for the utilization of the railways in war.

* 25,000 men, 3,000 horses, 300 guns and wagons.
† 60,000 men, 10,000 horses, 2,000 guns and wagons.
‡ 160,000 men, 21,000 horses, 3,600 guns and wagons.

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THE FRANCO-GERMAN WAR OF 1870–71.

The difficulties which arose during the French mobilization form a most instructive lesson. Railway Operations in France, 1870.

There was then in France no central controlling authority. That such must have been the case is shown by the fact that the French railway officials had to obey conflicting instructions from all sorts of different people, acting without any kind of concert or combination. Not only were these orders contradictory, but they were often cancelled and changed even while they were in process of execution. This soon resulted in confusion; the stations were choked with troops and stores, the available rolling-stock was not utilized to the best advantage, and the railway staff was hopelessly overworked without achieving any appreciable result.

It is, therefore, absolutely necessary to have all railway operations under the direct control of a strong central military authority. Failing this, but little is to be expected of the railways when mobilization is ordered. War is a business to be taken very seriously, and it is necessary for success to have all conflicting interests under control. This control can only be exercised by Army Headquarters.

Besides the want of a central directing authority, the French in 1870 found themselves involved in difficulties owing to the want of Regulations for the transport of troops by rail in time of war. No Regulations.

The transport of masses of troops, which will have to be undertaken in future wars, requires most perfect organization, including the utilization of time, personnel, and materiel to the best advantage. This can only be secured by regularity in military traffic and uniformity in the loading of trains.

The French Railway Companies attempted to please the public as well as to obey the military authorities. As a result, the running-tables were unpractical and unsatisfactory to both parties. They had to be constantly revised, and proved, for this and for other reasons, to be very ill adapted to military requirements.

As regards the rolling-stock, there was no law in France which enabled the Government to "commandeer" rolling-stock when required. Any branch line might refuse to transport troops on the ground that it could not spare the necessary rolling-stock. No instance of such refusal is recorded, but the absence of power to give orders in such a case was one of the defects of the French system.

Entraining was in many cases delayed owing to the absence of ramps and docks for loading and unloading horses. This involved further disorganisation of the transportation system.

No attention had been paid in France to the requirements of railways as regards personnel in time of war. Many of the railway employés had to join the colours, so that the railway staff was actually reduced instead of being increased to stand the extra strain. The natural result was that the staff was unable to keep pace with the work. To repair the error, the French authorities ordered soldiers to be employed to assist the railway men in shunting and similar labour. But the soldiers neither

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liked nor understood the work, and performed it carelessly and lazily; this led to trains being blocked and even to collisions.

We in Austria have taken warning by these misadventures, and have so regulated the liability to military service of the railway employés that in case of war the railways will always have a full staff available.

Military Labour.

Should it be necessary to fall back on military labour to assist the railway staff, it ought to be sufficient, to ensure that the work is properly done, to impress upon the soldiers the extreme importance of securing smooth and rapid working of the railway. Once you get the soldier to understand that even greater results can be secured by the efficient working of the railway than any he could achieve with his magazine rifle he will no longer be found wanting in zeal.

Want of Preparation.

The working of the French railways in 1870 suffered not only from the absence of a controlling authority but from the lack of peace-time preparation.

On the 15th July, 1870, the railway companies concerned received orders (from the Minister for Public Works) to be ready *next day* to transport large masses of troops! It is difficult to understand how any intelligent person could have issued such an order. The time available for preparation was limited to a single night. The entraining actually commenced on the evening of the 16th; but by the 22nd the arrangements had broken down owing to deficiency of locomotives and drivers, and the movement of troops had to be suspended for several days.

During the days which followed, the railway authorities were frequently ordered to transport troops and the order afterwards cancelled. In some cases transport was ordered for infantry, and cavalry and artillery arrived at the station instead; these of course could not be conveyed in the carriages intended for infantry. Troops when already on the move to entrain found their departure countermanded at the last moment; and many similar contretemps occurred.

Owing to these mistakes, and to the fact that the regiments on arrival at the station varied very much in strength, some of the trains started nearly empty while others were overcrowded. Sometimes portions of units had to be left behind; no provision was made for taking them on with other troops, and the men finally wandered away and never rejoined. Thus, at the end of August, the railway station at Rheims was encumbered with several thousand of these lost sheep. These unfortunate occurrences not only interfered with the work of transportation but exercised a prejudicial effect on the morale of the Army.

These few instances are sufficient to show that strict discipline is an essential factor in the conveyance of troops by rail.

We may note here that although troops may suffer from the discomfort of long railway journeys in crowded carriages, this must be set off against the fatigues which they would have to endure for days in succession during a march by road.

French and German Results.

If, in spite of the difficulties above outlined, the French managed to transport 200,000 men, 30,000 horses, and 4,000 carriages to their north-eastern frontier in 14 days, this is to be ascribed to the completeness of their network of railways, the liberal equipment of rolling-stock, the shortness

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of the distances to be traversed, and the exemplary zeal of the railway personnel.

In the same period the Germans, although they had far greater distances to traverse, succeeded in transporting to their western frontier more than double the above number of men, horses, and wagons. This remarkable result was chiefly due to the perfection of their peace-time preparations, which were carefully thought out down to the most minute detail.

French Railways in German Hands.

But even the Germans did not get through the war without experiencing many difficulties as regards railway transportation. These occurred mostly during the later period of the war when they began to make use of the French railways.

Defects of German Organization.

Although it must be admitted that it was no light undertaking to take over the running of 2,500 miles of an enemy's railways, yet the chief cause of the friction which occurred was the defective organization of the German Field Railway Staff. The personnel were imperfectly acquainted with the special conditions under which railway work has to be done in war. No staff of technical experts, skilled drivers, etc., existed in peace-time, and there was no organization for the upkeep and repair of railway materiel.

In Austria we have taken this lesson to heart, and the result is embodied in our Regulations for the organization of field railways and for the Corps of Military Railway Men. We have, moreover, a special corps trained in the upkeep and working of railways, namely the Railway and Telegraph Regiment.

It is useful to study books of military history in which past events, as affecting the subject of railways in war, are described. I would particularly direct attention to a book published at the end of 1903, edited by the German Minister for Public Works (von Budde), and entitled *The French Railways under German Management, 1870–71*. I strongly recommend this book to all who in war will have to do with the military employment of railways.

I will now describe some of the difficulties which the Germans experienced in working the French railways in 1870–71.

Destruction of Railways.

In the first place, they found the permanent way damaged or destroyed in many places. As they advanced further into the country, and the hostility of the population increased, such instances became more and more common. In all, 78 large bridges and tunnels were destroyed and many miles of permanent way torn up.

Much time and heavy labour was required to repair these damages, and difficulties were experienced in obtaining building materials for the temporary constructions. In cases where tunnels or cuttings in even moderately unsound soil had been destroyed, it was found better to immediately lay a diversion than to waste valuable time in attempting repairs.

Raids on Railways.

Since 1870 railways have assumed so much importance as a means of offence and defence that in future wars the adversaries will be tempted, even more strongly than before, to undertake dashing raids with the object of destroying the enemy's railway communications. The importance of the prospective result will justify the acceptance of considerable risks.

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It is therefore essential to discount the importance of such exploits, even if successful, by making preparations beforehand for the rapid repair of the line.

French Rolling-Stock Withdrawn.

Another difficulty experienced by the Germans in 1870–71 was the want of rolling-stock for the French railways of which they had taken charge.

As the French troops retired the railway rolling-stock had mostly been withdrawn, or, if this could not be done, had been destroyed. The facilities afforded by the small stations were scanty; the large stations, being within the enceinte of fortified towns, remained for many months in the hands of the French. The want of platforms and loading-docks caused delays which much impeded the military traffic and prevented the utilization of the available rolling-stock to its full capacity. In spite of constant reinforcements of engines and trucks from Germany, serious difficulties arose. The various Commanders had a way of seizing railway material when required for the movements of their own troops. They did not scruple to "commandeer" engines which had been detailed for the regular service of the line. These high-handed measures, though they relaxed the pressure at one point, seriously increased it at others; and it frequently happened that the regular train-service ordered by the directing authorities was brought to a complete standstill.

Our own regulations provide against these unjustifiable encroachments by local authorities upon the general strategical train service. But it will none the less be necessary to exercise strict supervision over the circulation of rolling-stock. This is one of the most difficult questions connected with the management of railway traffic in war.

Transfer of Rolling-Stock.

Another difficulty lay in getting the available rolling-stock to the places where it was wanted. It often occurred that portions of line captured from the enemy were cut off from the base, either because the line passed through towns in the enemy's hands or because bridges, etc., had been destroyed. In such cases it was necessary to haul engines and trucks *by road* from one point on the railway to another. The Germans had to overcome immense difficulties, and the history of the means which they adopted to surmount them is even now most instructive. For many of the adverse conditions of the Franco-German war will certainly be repeated in the future, although, with the assistance of our modern Railway Regiments, they will be easier to deal with. It is most desirable that our Railway troops should gain experience in peace-time of the transport of railway engines and trucks by road.

Locomotives.

Running conditions in war are very different from those prevailing in peace-time. Drivers and stokers are unskilled, unaccustomed to their engines, and strange to the line. The coal is often bad, and the engines are not properly cleaned and oiled, which seriously increases friction. There is no time to thoroughly inspect the trucks, nor to grease them properly. All these disturbing causes reduce the effective power of the locomotives by from 20 to 25 per cent.

Electric Traction. Compared.

While on the subject of locomotives I will say a few words about electric traction for use on main lines.

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From the military point of view the following points require attention :—

The dependence of the system on one or more central power stations.

The liability to damage of the conductors.

The difficulty in replacing or supplementing the electric engines and their drivers.

If a central station is disabled, this stops the traffic over a long section, and it may take many days to re-establish it. Malicious or hostile damage to a power station must be reckoned with as a possibility, especially in the case of power stations near the frontier. Such an occurrence would have the most serious effect upon the mobilization and deployment of the army.

The same applies to the conductors, except that these are more easily destroyed and are exposed to damage at many different points.

Not only hostile acts, but accidents of all sorts, including lightning, storms, and heavy snow may disable the electrical system at any moment. How often we find our telegraph and telephone lines destroyed from these causes! Electrical power is therefore far less reliable than steam.

The use of electric locomotives on only a part of the railway system would render the whole railway system far less elastic and inter-supporting. And so long as electricity is used on a few lines only it would be most difficult to provide additional electric locomotives to increase the capacity of these lines in time of war. In view of the immense amount of capital sunk in steam locomotives and their accessories it will be long before they are replaced by electric tractors.

The partial introduction of the electric system would force us, on mobilization, to re-introduce steam on the electric lines, and this at a moment when all the railways would be worked to their utmost capacity. This, moreover, would involve a sudden change to a system unfamiliar to the lines in question and to their employés.

The only advantage of the electric system from a military point of view is that it requires fewer men to work it and possibly allows of a higher rate of speed for troop trains.

Personnel.

Before leaving the subject of the difficulties experienced by the Germans in running the French railways, I must refer to the trouble which they had with their railway personnel.

Men to replace the French railway staff had to be imported in large numbers from the German railways. But as at that time the German railways differed considerably both in the nature of their equipment and the training of their employés, considerable friction arose when these men had to work together. The German railway men were taken from 26 different lines, and it took some months and a great deal of petty squabbling before they settled down to work together. This is one reason why the performances of the captured railways fell far short of expectations.

This was also due in part to the loose discipline of the railway men and to the friction which at first frequently occurred between the railway officials and the troops, leading to great difficulties and serious misunderstandings. These again led to friction between the different classes of railway employés, which, in the case of men of a too independent

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disposition, produced most undesirable results. To these sources of confusion must be attributed the fact that many railway officials of long-standing good character were guilty of serious offences of insubordination, indiscipline, and indolence.

Since those days we in Austria have done much to diminish the above difficulties by the establishment of a Field Railway Corps and the introduction of a uniform system of construction and signalling on all our lines. But difficulties will nevertheless inevitably occur, and much is still wanting to ensure that our staff of railway men in war will fall into line at once and work together. And the first essential for this is that they should be able to understand one another.*

THE RUSSO-TURKISH WAR, 1877–78.

1876. I will now consider the railway mobilization of the Russian Army in 1876, and the concentration by rail on the Turkish frontier in the autumn and winter of that year.

The transportation of masses of troops by rail had never before been attempted in Russia, and to this may be ascribed many of the difficulties that arose. These were so serious that, if Russia had been opposed to a powerful enemy concentrated near the frontier, the results would have been disastrous for her, and the neglect of the railways in peace-time would have been severely punished.

Russian Railways. The Russian network of railways existing in 1876 had almost all been constructed by private companies, who naturally built as cheaply as possible. The railways were laid out without any reference to military requirements and their equipment left much to be desired. They were nearly all single lines, built with steep gradients and sharp curves, and (especially in winter) were only suited for the running of short and light trains.

The stations were small, the sidings few and short. No wonder that the sidings quickly became choked.

The watering stations were too few and inefficient, the loading appliances defective, and the rolling-stock insufficient.

Russian System. The management of the railways in war was in the hands of a Central Committee, to which officers of the General Staff were attached as transport officers. The most important stations were under the command of Military Station Commandants.

Railway regulations for war existed, and there was a stock of equipment for the conversion of covered goods wagons to carry troops.

When, in 1876, relations with Turkey became strained and a partial mobilization seemed probable, the Committee, at the end of September, received orders to prepare plans for the mobilization and transport by rail of six Army Corps. Four were to move on Kischeneff, one on Odessa, and one on the Crimea.

But the Committee had only prepared plans for a general mobilization; so these plans had all to be revised, which took some time. Hardly had this work been completed, when, on the 24th October, the Committee

* *Note by Translator.*—Besides German, Hungarian, and Italian, 20 minor languages are spoken in Austria.

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were informed that fresh alterations in the plans had become necessary. The mobilization scheme had to be worked out afresh, and, to cope with various difficulties that had arisen, the transport officers and the traffic managers were invited to a Conference at St. Petersburg.

The first outcome of this Conference was a circular, directing all lines to send in returns of rolling-stock available and to commence at once the construction of snow-guards to protect the lines from drifts. The railways were further enjoined to cease the acceptance of private goods from the moment of mobilization; all trucks then in transit were to be despatched to the stations where they were required on mobilization, and there unloaded. Finally, it was ordered that the Southern railways, which had most work to do, were to receive 572 locomotives from the Northern railways; but nothing was said as to when and where these locomotives were to be handed over. As will be seen, this omission was the source of much subsequent trouble.

The imminent commencement of mobilization rendered it necessary to close the Conference on November 14th before it had completed its work. This may perhaps be excused by the fact that this was the first time that the transport of masses of troops over the enormous distances of the Russian Empire had ever been attempted.

Mobilization began on November 17th. But within a week all military traffic had to be stopped, partly because the Odessa railway had run short of engines, partly because the Northern lines were choked with the engines and trucks intended to be taken over by the Southern railways. The Odessa railway could not take over the locomotives allotted to it, because the fire-boxes were constructed to burn wood while the Odessa railway used coal. Mobilization.

To evolve order out of the chaos created by their hasty and ill-considered scheme, the military authorities had to suspend the transport of troops for three days, November 24th to November 27th, and to postpone the eleventh day of mobilization to the latter date. This is a striking proof of the necessity for thorough peace-time preparation.

The sudden transfer of a large number of locomotives at a moment's notice caused considerable confusion, which could only have been avoided by the preparation beforehand of detailed and carefully-worked-out plans. Transfer of Locomotives.

We further learn from the experience of the Russians that it is most difficult to put strange locomotives on to a line unless the lines all use the same fuel. In this case the locomotives were of several different types, intended respectively for firing with coal, wood, petroleum, and heavy oil. To run them on other lines the fire-boxes had to be specially fitted or adapted, which took a considerable time and delayed the despatch of the locomotives. It is clear that in future special attention must be directed to uniformity of grate-construction.

The transport of troops to the base began on December 2nd. The plans for this transport had been issued on the 14th November (the first day of mobilization) in the following manner:—

Each Division received orders to send one officer of its staff to the nearest railway station to await orders. A messenger from Headquarters brought the plans for the movement of the whole Division, handed them

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over to the staff officer, and directed him to communicate them without delay to the units concerned. Army Corps, Districts, and Chief Transport Officers received their plans direct from headquarters.

But no sooner had the plans been issued than they had to be revised, partly in consequence of fresh movements of troops being ordered, partly in consequence of others being countermanded. The entraining arrangements had also to be modified, as many units were unable to reach their entraining stations on account of the snowstorms and the severe frost. These had therefore to entrain at stations nearer at hand, although without proper entraining facilities.

Transport of the General Staff.

Additional trouble arose over the incorporation of extra trains in the time-table. The greatest difficulty arose over the transportation of the Army Headquarters. The trains allotted to this service were timed so as to run at the period when the line was most fully occupied with the transport of troops.

Following the example set by the King of Prussia in 1870, it was at first proposed that the Army Headquarters should travel in troop-trains. But both on account of the cold and of the length of the journey this intention was abandoned, and special trains were run. I need hardly say that this entailed serious disturbance of the military time-table.

Water-Supply.

In the meantime a fresh contretemps threatened to stop the traffic. The water-tanks and hydrants at several stations on the Odessa line, where they were most required, became unserviceable, and trains were brought to a standstill. This block on the main line also affected the branch lines, which had to beg for a four days' rest as their stations were getting choked.

But in consequence of the unsatisfactory result of the previous three days' stoppage, this request was not granted, and the authorities merely reduced the traffic on the most overcrowded section, from Zmerinka to Birzula. To this end 55 troop trains were either struck out altogether or stopped at Zmerinka, where the troops had to disentrain instead of going on to their destination at Birzula. These troops were sent on afterwards by supplementary trains.

It may be imagined what confusion in the constitution of army corps and in the supply of the troops was caused by this proceeding. That no serious consequences ensued was due to the fact that the war did not begin at once and that Turkey was unable to take the offensive.

Delays.

Many troop trains were delayed during mobilization and concentration, principally by the snowstorms which raged throughout Russia in December. Throughout the whole operation the railway traffic was much affected by the weather, which reduced the speed of the trains and delayed the march of the troops to the entraining stations.

But many of the delays were due to the unpunctuality of the troops in arriving at their entraining stations, owing to their not understanding the plans issued to them, and not appreciating the importance of exact compliance as regards the times laid down. Moreover, many of the units were ignorant of the procedure in railing troops in war. Some regiments demanded trains entirely composed of passenger carriages and others required the trains to stop at stations for as long as suited

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their own convenience. This was due to the troops having never been practised in entraining in peace-time.

Owing to the extreme cold of the weather the Russians found it necessary to arrange for special fittings for the covered goods wagons for the troops. It was at first proposed to cover the floors with straw and to lay straw mats on this; but although this was found by experiment to be satisfactory, the plan was abandoned on account of the danger of fire. The straw was therefore replaced by felt, which answered very well. Later on, as the cold became more severe, the railway companies, on their own initiative, either fitted several wagons of each train with stoves, or arranged for the attachment to each train of a third-class coach with warming apparatus. This rendered it possible for the men who were being frozen in the covered wagons to take it in turns to get warmed. Warming Appliances.

Further, the railway companies provided at their own expense tea, rum, and wood for camp fires for the men. The last in particular was a great boon to the troops, who often had to make a march of several days to the railway and to entrain at a station far from any habitation.

Similar measures were adopted on the Trans-Siberian railway during the recent war. The walls and floors of the covered goods wagons were covered with felt, with a layer of boards over; glass was fitted to the window openings, and a stove erected in each wagon. Buckets were provided in case of fire.

To make the long journey as easy for the troops as possible, special measures were adopted. The covered goods wagons were provided with planks, which could be so arranged as to allow from 28 to 32 men* to lie at full length all night.

Arrangements were also made to serve out boiling water from time to time to make tea, for which purpose a kitchen wagon was attached to each train.

THE GRÆCO-TURKISH WAR, 1897.

A striking example of the evils arising from want of peace-time preparation is afforded by the experience of the Turks in 1897. The confusion which occurred would certainly have led to disaster but that the Greek forces were inferior and unfit to take the offensive. 1897.

The Army Corps transferred from Asia Minor to the base had been allotted the line Muratlue-Feredjik-Badoma-Saloniki. This line was but poorly equipped for the transport of a mass of troops, and the small station of Muratlue, where they had to entrain, was utterly unfit for the purpose. It had accordingly to be rebuilt and enlarged, partly before and partly during the operation. The result was that of 72 battalions to be transported the last did not get off till a month after the first had started!

In spite of this very deliberate despatch of the troops, the line was

* The covered goods wagon usually holds 56 soldiers.—*Translator.*

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repeatedly blocked, more than once for several days at a time. No preparations whatever had been made; rolling-stock was lamentably deficient; the railway employés were few in number and untrained; and finally, the section Feredjik-Badoma was very badly laid out. To get over this section the trains had to be divided; this seriously delayed the traffic (it was not unusual for trains to be two days late), and the line was often blocked with trucks for days at a time.

This accounts for the small number of trains despatched, which never exceeded 6 per day. Even that number was only occasionally attained. Sometimes for a week at a time only 40 trucks per day could be despatched.

Strong Measures applied by Turkish Government

But the Turkish government adopted summary measures for putting a stop to this state of things. This was due principally to the two accidents which occurred on the night of the 12th—13th March. The first of these was a collision between two trains near Jenikoi; the second the collapse of a bridge at Saloniki, by which a troop train was precipitated into the Vandar river, causing great loss of life and materiel. The Sublime Porte then telegraphed to the railway company that unless their line were set in order at once it would be confiscated. The effect of this salutary measure was that the railway company immediately set about borrowing efficient locomotives and trained men from other lines. Within 3 days they were despatching 125 wagons per day.

Another serious accident took place on the 30th March. A train ran off the line on the difficult section between Feredjik and Badoma, and blocked the whole line till April 15th.

Inaction of Turkish War Office.

The above difficulties were due principally to the characteristic methods of the Turkish military authorities. They did not concern themselves about the details of the transport of troops; they left all such matters in the hands of the railway and steamship companies. These companies were allowed to fix the amount of transport provided, the time of transit, and such matters, at their own convenience.

At the end of February a committee of Generals to supervise railway transport was formed in Constantinople. As however they had no information about the construction and equipment of the railways, or about the amount of rolling-stock available, their functions were merely nominal.

CONCLUSION.

It is a matter of the highest national importance that, in the hour of danger, we should be able to mobilize our troops and convey them to the threatened frontier as quickly as possible. To effect this we must bear in mind, in the laying-out and construction of our railways, the military necessities of the nation. Our people must understand that any neglect in organizing our railways for war becomes a matter of grave national danger. And finally, our railway companies must appreciate and understand their duty, so that at the critical moment they will act in concert, on their own initiative, for the defence of our country.

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The effect of railways is to expedite the decision of the issue of war. May this great fact be fully realized in framing our military plans! And may the great body of railway men look forward with ever-increasing enthusiasm to sharing the duties of our Army in the protection of our homes!

May we never forget that to ensure victory we require not only an efficient army but a well-organized railway system; not only well-trained officers and soldiers, but highly-skilled and zealous railway men.

I cannot better conclude my lecture than by quoting the words used by the Prussian Minister of Railways regarding the railway mobilization of 1870:—"And our railways, too, have borne their part in achieving the glorious victories of our Fatherland."

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NOTICES OF MAGAZINES.

Bulletin of the International Railway Congress.

November, 1906.

Suburban Traffic.—Two reports, by Mr. Drury of the G.E.R. and Mr. Sullivan of the Illinois Central, formed the basis of a discussion at a Congress Meeting. These showed that just as the conditions were in many respects different in Europe and America differing methods were adopted to meet them. It is fairly clear however that, generally speaking, in Europe the pressure is greater because the increase of facilities is attended with greater difficulty. For all that it is only in recent years that the daily movement of population to be handled has really become intense.

The principal points round which discussion ranged were :—

(1). Maximum density of traffic workable—the best way of moving a sufficient number of trains on the line and the planning of timetables making provision for irregular running.

(2). Engine power and acceleration of trains, with which is involved the question of electrical working.

(3). Duration of stops and best arrangement of carriages to ensure rapid loading and discharge of passengers. Opinion seems generally to incline to side-door carriages with plentiful gangway space. The type of carriage brought out on the Illinois Central is now well known.

(4). Ticket issue and collection, and station arrangements.

Besides the general aspect of the suburban traffic question it must not be forgotten that in many places in and out working is much complicated by junctions, and of course the question of the most economical train workings, *i.e.* best utilization of rolling stock, is one always before traffic managers. These questions have to be solved according to local conditions in each case.

Electrical working seemed, generally speaking, to be successful, mainly perhaps because of the ease with which a more frequent service can be maintained and the possibilities of economically varying the output of power. In America electrical trains are, it is stated, being run with less staff than those driven by steam. One American speaker asserted that generally in that country the workers went out of town to their employment instead of the reverse as here, but it seems rather a sweeping statement.

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January, 1907.

SCREW AND CRAMP FASTENINGS FOR PERMANENT WAY.—Much attention has been paid of recent years to the strengthening of the road to resist the wear due to increased speeds of trains, and elaborate investigations have been conducted into the behaviour of the road under the moving load, so that by this time the nature of the movements which take place is pretty well known. Little seems as yet to have been done, however, to investigate exactly the conditions under which the various component parts of the permanent way do their work.

The article under notice, after remarking on the various stresses set up by the moving load, points out that one of the sources of weakness which most seriously needs to be combated is the tendency of the fastening between rail and sleeper to work loose. Practical experience has certainly shown that screws are much more satisfactory as fastening between rail and sleeper, at all events in the case of Vignoles rails, than any kind of spike.

With a view to improving the design of such screws the article proceeds to investigate the forces which cause screws so employed to work loose. It must be remembered that the screw, bearing as it does at one side only on the foot of the rail, has not to resist a direct drawing force but a force applied at one side and at an angle to the direction of the core. An analysis of the reactions shows that but a small portion of the helix does useful work, and indeed that the reactions developed from a large portion of the surface actually tend to loosen the screw. The next step then is to determine whether any alteration in the design would produce more useful working surface and diminish the disadvantageous portions. This line of investigation does not, however, lead to anything satisfactory; the theoretical design would not be practical.

It is then for consideration whether some modified fastening would not be an improvement on the screw. I should at this stage remark that the author is more especially considering the attachment of a rail to a steel sleeper, but his arguments would apply equally to a wood screw so far.

The result of the examination is to propose the use instead of a screw of a cramp, *i.e.* a fastening which will grip the foot of the rail with its head, its shank passing through the sleeper and its foot bearing with sufficient surface on the underside, the tightening up to be effected by a wedge passing between the foot of the rail and the upper surface of the sleeper. There seems to be much in the idea, the wedge and screw are of course the same nature of tightening arrangement applied in different ways. The precise pattern of the fastening is not discussed, however, and one sees certain practical difficulties, so that experiment would doubtless be necessary to ascertain the best design. The use of wedge or cotter fastenings ought not to be inimical to rapid laying.

C. E. VICKERS.

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JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

January, 1907.

RECENT PROGRESS IN AËRIAL NAVIGATION.

A lecture by Colonel J. D. Fullerton, late R.E., which is too full of details to be adequately dealt with in a notice.

Dirigible Ballooning.

The chief characteristics are:—

1. The weight of the whole machine is supported by a balloon or bag filled with some gas lighter than air (hydrogen being the most suitable), so that no power is required to support the apparatus.
2. Forward motion is obtained by means of a motor actuating a propelling instrument, in the same way as in a steamship.

The author deals severally with Constituent Parts, Forces acting on the Balloon in Flight, Stability (longitudinal and transverse), Power required for Propulsion, Balloon (or envelope), Ballonet, Gas, Jacket (or net), Suspension Apparatus, Car, Fuel, Motors for Propelling, Steering (horizontally and vertically), Stability Apparatus, Rising and Landing Apparatus, Storage House, and Miscellaneous Fittings (*e.g.* searchlights and photographic stores).

As regards the *Envelope*, since a considerable proportion of the air resistance is due to the envelope, it is of great importance to make it "fair shaped." A spindle (or torpedo) form, with a ratio of length to diameter of about 6 to 1, the maximum diameter being about $\frac{1}{5}$th of the length from the front, appears to give the best results. Skin, as used in the British service, is the best material; but it is expensive, and foreign countries use silk or cotton varnished with some sort of india-rubber solution.

The *Ballonet* is a small balloon, filled with air, which is placed inside the main envelope in order to keep it tight and in proper shape. An air pump in the car regulates the pressure in the ballonet, which in its turn increases or lowers the pressure of the hydrogen in the balloon and thus enables the proper shape to be maintained.

Longitudinal Stability presents one of the great difficulties in connection with dirigibles. The various forms of apparatus for controlling it are:—(*a*) Rolling Weights; (*b*) Liquid Balances, consisting of tanks of water, usually one under the forepart of the balloon and one in the rear, in which the water is alternated by a pump in the car, the pump being put in action by a pendulum which starts it working whenever the inclination of the balloon exceeds a certain amount up or down; (*c*) Adjusting Planes, fixed fore and aft; and (*d*) Fish Tails on the principle of the tail of an arrow.

Rising and Landing.—The former is controlled by utilizing the ascensional force or by using special adjustable aero surfaces, and the latter by the last-named fittings. These purposes can, of course, be effected, when necessary, by throwing out ballast and letting out gas.

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Details are given of the *Principal Types* of dirigibles,—the French "Santos Dumont No. 6" and "Lebaudy I. and II.," the German "Zeppelin I. and II.," and the "Italia." The "Santos Dumont No. 6," in October, 1901, succeeded in making a tour round the Eiffel Tower from the Parc d'Aerostation at St. Cloud, the distance of 16 kilomètres being covered in 29½ minutes, the velocity approximating to 20 miles an hour. The "Zeppelin" balloon is remarkable for the material of the envelope (aluminium) and its shape (cylindrical with conical ends); also for its great size, No. II. being 410 ft. long and 38 ft. in diameter. In October, 1906, No. II. manœuvred over Lake Constance, rising to a height of about 450 ft. and attaining a velocity of nearly 30 miles an hour.

Flying Machines.

These are of two kinds, viz. Soaring and Driving; the former are never likely to be useful in practice. The chief characteristics of Soaring Machines are:—

1. The weight is supported by the pressure of the air on a part of the machine called the 'sustainer.'
2. Motion in any direction is obtained by combining the force or the weight with the resultant air pressure on the whole machine. No artificial power is required.

The chief characteristics of Driving Machines are:—

1. Weight supported by 'sustainers.'
2. The motion in a given direction is obtained by a propelling instrument worked by a motor.

The author again deals with the various points enumerated above under the head of Dirigible Balloons. He recommends the construction, at present, of three sizes:—

Load.	*Weight.*	*Velocity.*	*I.H.P.*
1 passenger	800— 1,000 lbs.	30 miles an hour.	20 —25.
2 passengers	1,000— 1,500 ,,	35 ,,	25 —35.
4 passengers and 1,500 lbs. of stores	7,000—10,000 ,,	35—40 ,,	250—300.

The large type would be suitable for military reconnoitring work, and would carry a light gun for use against hostile machines and a special gun with heavy shells for use against ships or troops.

Sustainers are of two classes, viz. single surfaces and superposed surfaces. The former are large flat or curved surfaces formed of varnished cloth or canvas on steel framework, great care being necessary to make them airproof. The superposed surfaces are usually very narrow and fixed one above the other, the best material apparently being wood.

Oil or Spirit Engines seem at present to be the best for aeronautical propelling work, being comparatively light and economical in fuel, the fuel moreover requiring little stowage room.

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Propelling may be done by (*a*) Jets, (*b*) Paddles, or (*c*) Screws. The two first forms are unsuitable for aeronautical work. Screws may be of the wing (or bird) class or of the ordinary marine type, the latter being the best.

Stability is effected by aero surfaces controlled by springs, pendulums, etc. As in balloons the main point is to have the centre of gravity well below the centre of pressure of the whole construction.

Rising and Landing.—For rising inclined planes or springs are used; but the true flying machine is one that can rise by its own unaided power. The best plan comprises specially prepared smooth rising tracks, along which the machine can run under its own motive force, actually rising when the velocity required to produce the necessary lifting power has been reached.

Some particulars are given of the *Principal Types* of Flying Machines,—the Maxim, the Phillips, the Langley, and the Wright,—but information as to details and trials is difficult to procure. The Wright machine, in October, 1905, made a circular trip in the air of some 36 minutes duration and attained a velocity of 40 miles an hour. Other inventors engaged in this science are Santos Dumont, Bleriot, de Vaux, and Vuia.

Present Position of Aeronautics.

The author considers that *Dirigible Balloons* do not seem a satisfactory solution of the problem of flight. They must be of considerable size to carry any reasonable weight; their speed is limited; there are many difficulties in construction and management; and, contrary to the popular idea, they cannot rise or descend at any time and anywhere, but require a land harbour.

Flying Machines appear to present the best solution. There is now no reason to prevent the construction of good serviceable machines to travel at 30 to 40 miles an hour; and their cost, omitting experimental expenses, need not be more than that of good motor cars.

In War Flying Machines will be regularly employed in the future against other airships and against sea and land forces. For purely aerial warfare both sides will maintain high-speed machines, armed with light guns, and well supplied with fuel so as to possess a large sphere of action. Against ships Flying Machines will be useful for reconnoitring, especially of submarines, and for dropping projectiles on to decks. (In regard to reconnoitring the lecturer quoted the Rev. J H. Bacon, who, in a voyage across the Irish Channel, took photographs which clearly showed rocks, sand, etc., under 60 ft. of water; and in the subsequent discussion, Colonel J. E. Capper, R.E., related how, when passing recently over the muddy waters of the Medway, at a height of 1,500—2,000 ft., he could clearly see the tortuous channels and could easily have directed a ship's course). Against land forces they will be used principally for reconnoitring, but will also be effective in other ways such as setting fire to store depôts. (In this connection we may refer to a thrilling story in the January *Blackwood*, in which a brother officer, 'Ole Luck Oie,' describes how the repairing of an important bridge, on which depended the further fighting power of an army in front, was frustrated,

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almost at the very consummation of weeks of arduous labour, by a mosquito fleet of air-ships).

In Commerce the lecturer sees an opening for postal and light parcel work, and thinks that it will be quite possible to carry passengers and light goods at remunerative rates.

In conclusion Colonel Fullerton urged the appointment of a Royal Commission to consider the whole subject of aerial flight; and we believe that, with the lead of the Aeronautical Society of Great Britain, an association has just been formed for this purpose, the committee of which includes Colonel Fullerton and Colonel Capper.

ORGANIZATION WITH SPECIAL REFERENCE TO PREPARATION FOR WAR.

An anonymous writer 'communicates' a most valuable essay, which everyone should read in the original.

He commences by remarking on the corrupt and illegitimate use of the word 'organization.' Its most important correct meaning denotes the science that deals with the principles under which a body or agency is furnished with organs having special functions, mutually dependent, and all essential to the healthy life of that body; a secondary meaning refers to the application of this science to a particular body or agency. The word is erroneously used, instead of 'organism,' to denote the body itself; and instead of the words 'preparation,' 'arrangement,' 'plan,' etc., which signify the attainment of a certain purpose by means of the agency and not the formation of the agency itself.

All alterations in military organization are due to an attempt to forecast the future, to improve on the past, and, with the knowledge of recent experience, to adopt changes that will produce better results than before. The author discusses how such changes conform to the principles of organization, of which he chooses the following for consideration :—

1. Definition of Object or Purpose.
2. Sufficiency of Material.
3. Proportion of Parts.
4. Relation of Parts.
5. Necessity of Central Control.

1. *Definition of Purpose.*

A clear idea must first be formed of the object for the attainment of which the organism exists or is to be created. Sometimes there is more than one object involved: when they do not conflict the more important usually include the less; when they differ a compromise becomes necessary.

In military organization this principle is frequently ignored. France, Germany, Switzerland, and Japan are nations that organize their military forces in accordance with this principle; in our case it is only recently that proper attention has been paid to it with regard to our Regular Army, and it has been almost entirely neglected with reference to our Auxiliary Forces.

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The conditions of our Empire render it impossible to state the purpose for which our Regular Army is required, or the conditions under which it will take the field, with such exactitude as can be done by the other nations mentioned. But success in war depends upon complete preparation in peace, such preparation including the accumulation of equipment in precise quantities for units whose exact war strength must be known to all concerned. Our naval supremacy will not secure us time to complete our preparations for war when the war comes upon us; and in the case of some great wars that are possible every hour's delay will imperil our success. The British military authorities have always worked upon a normal organization for service in a civilized country with a temperate climate. All other cases, some far more likely to occur, are treated as exceptional, because time would be of less importance and conditions cannot be definitely foreseen.

As for the Auxiliary Forces the only 'purpose' that has had any concern in our treatment of them is covered by the term "Home Defence." In attempting to establish more definite objects we were met with the conflicting argument of the 'Blue Water School.' Moreover, plans for Home Defence have been framed on the existing strength and condition of the Auxiliary Forces; they have been made to suit the composition of the forces instead of the forces being made to suit the plans.

If, however, for Home Defence we substitute Imperial Defence, we have at once a purpose common to all the services, from which the purpose of each can be determined.

2. *Sufficiency of Material.*

In armies raised on a system of universal service the available material, with certain exceptions and within certain age limits, consists of the whole manhood of the nation. The proportion between the strength of the army and that of the whole manhood may vary; but the principle of designing the organism to suit the available means is always observed.

In England the available material could be assessed as easily as elsewhere. Under our voluntary system, however, it is not all available. In the Regular Army the principle is observed, for conditions of enlistment, pay, and service are varied until the requisite numbers are obtained. In the Auxiliary Forces, however, though every man can be called out in the extreme emergency of an invasion of Great Britain, we cannot even estimate the number of men on whom we can rely for service over sea,—it may be anything from 1,000 to 300,000; under these circumstances organization is impossible, because the principle is disregarded.

3. *Proportion of Parts.*

This is frequently overlooked, or recognized only with reference to comparatively minor details such as the number of guns to bayonets. But it must be studied, not only with regard to the strength of the various

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combatant arms, but also in the composition of every unit, whether combatant or administrative, which is required for service from the base to the outposts of an army in the field.

With our Regular Army this principle has usually, though not always, been observed. In the Auxiliary Forces the sense of proportion has been conspicuously absent, so that we have now an excess of some 20,000 of garrison artillery whilst some of the essential administrative services are entirely non-existent.

Naturally, and perhaps rightly, strategy and tactics attract most of the attention of military students; and the meagreness of peace establishments, coupled with imaginary units in manœuvres, is a contributory cause of the neglect of the principle of proportion of parts.

The value of an object lesson in organization, as against the false impression produced by half-formed units, suggests the advisability of completing a portion of manœuvre troops to full war establishments as was done last year in France.

Army Corps have recently been abolished, and enlarged Divisions have been established as the only independent, self-contained, and self-supporting fighting bodies. In the Field Army as now organized (viz. 1 cavalry division, 2 mounted infantry brigades, 6 divisions, and 1 line of communication) there are no less than 472 units of 68 types. Each type is a separate organism, designed so that it may fulfil its duties to the best advantage of the whole force. The new "War Establishments," which show the complete war organization of the Expeditionary Force, deserve to be studied in detail.

4. *Relation of Parts.*

This is just as important as the number of parts. Each part must be considered with reference to the common purpose of the whole body,—success in war. Each must be organized, not only to perform its own functions, but to assist others and to contribute through them as well as by itself to the common objects; this is called 'co-operation.'

The principle applies to the interior composition of the smallest individual unit as well as to the larger organisms; and in some cases (the battery) it is more important than in others (the company).

5. *Necessity for Central Control.*

However carefully a particular body may have been organized it is incomplete and ineffective without a directing and controlling power. In military organizations, though the will of the supreme commander must be communicated to every part of the body, command cannot be exercised efficiently over more than some half-dozen subordinates. It must therefore be delegated; and this delegation, from link to link in the chain, is the organization of command and is subject to the same principles as in the case of other organisms. The transmission of will power is the function of the staff, whose purpose is to facilitate it; the staff system must be coincident with the command chain, and is part of the organism of command rather than an organism itself.

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The Expeditionary Force.

The author then proceeds to examine how the above principles have been followed in the recent organization of an Expeditionary Force, the leading features being :—

(1). The increase of harmony in the relationship of the component parts.
(2). The strategical freedom attained by the Independent Cavalry.
(3). The establishment of the Division as the only independent fighting unit.
(4). The modifications, principally in artillery and engineer services, necessitated by recent experience and improved material.

(2). Cavalry must be prepared to defeat the enemy's cavalry whenever and wherever they are met. Formerly our cavalry brigades had the duty of protection as well as that of strategical exploration. The new cavalry division is set free for the latter task; and security is entrusted to the mounted brigades, each consisting of 1 cavalry regiment, 1 horse artillery battery, and 2 mounted infantry battalions.

(3). The Divisions are strategical units in the hands of the Army Commander. He disposes of the mounted infantry brigades as security troops in advance of the divisions, but he has no tactical functions with regard to the latter; and for this reason, no combatant force, other than the M.I. brigades, is included in the Army Troops, the infantry battalion and two squadrons of yeomanry being only for escort duties.

The new organization includes all the changes which have been approved in consequence of recent war experience and improved equipment. The most important concern the artillery and engineers.

"Judging from recent war experience in Manchuria and South Africa, the infantry attach greater importance than ever to the support of artillery fire, both in attack and defence. Not only is there justification for an increase in the number of guns, but it is also recognized that a combination of different classes of artillery fire will produce results eminently favourable to the action of the infantry. The shrapnel of flat-trajectoried field guns, the searching power of field howitzers, combined with the possible closer approach of the infantry under their steep descending fire, and the powerful shell of the heavy artillery, afford the means of producing greater effect, in the hands of a skilful commander, if employed in conjunction with each other than if they are treated separately. The allotment to the divisions of every nature of ordnance, except that of horse artillery, gives to the divisional commander the opportunity of using this enhanced effect to the fullest extent which the tactical conditions admit of, and to the greatest advantage as a whole of the division for whose action he alone is responsible. The additional personnel (orderly officers, range-takers, signallers, etc.) required to enable the artillery officers to use the whole of the combined artillery in furtherance of the wishes of the divisional commander is shown in "War Eastablishments." * * * The organization of the supply of ammunition, from the advanced depôt to the fighting batteries and battalions, is

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based on similar principles—viz., those of purpose, proportion, and relation of parts—which are, perhaps, better illustrated in the artillery than in any other arm of the service.

"The engineers are, perhaps, affected most by the new organization. The Manchurian War seemed to point to the necessity for considerable increase in the field companies for work in the fighting line. Allowance must, however, be made for the topographical and strategical conditions, which precluded lateral mobility to a great extent, and gave to the principal battles the characteristics of siege rather than field work, due to the frequent necessity for direct frontal attack. It is not, therefore, in this direction that we find most change.

On the other hand, this war fully confirmed what had been long known, that a development of the communication service is absolutely essential. Army headquarters now have two cable, two wireless, and two air-line telegraph companies; each division has its own telegraph company; while two are allotted permanently for line of communication work.

The field companies will, however, be expected to do more work than hitherto, especially in connection with the construction of all the bridges that may be required for the army. The actual equipment, except a small quantity for minor crossings, is kept well in rear in two trains, so as not to hamper the marching columns when not immediately required. This is in conformity with a general policy, which has been applied to the whole Army.

The inordinate amount of transport, which formerly accompanied the troops, tended to interfere with their mobility so seriously that their value as fighting bodies was considerably impaired. Transport has accordingly been reduced; so that the front line troops now only carry with them what is essential for fighting efficiency and health and to render them independent in these respects for a short period of about a fortnight. All else is put further back in the line of march, its distance in number of days of march from the front depending on the frequency and probability of its being required."

A. T. MOORE.

REVUE DU GÉNIE MILITAIRE.

December, 1906.

THE SIEGE OF PORT ARTHUR.—A review of a pamphlet published by the German General Staff. It appears from internal evidence that the writer of the pamphlet was not in possession of any more information than has already been made public. For this reason the chief interest of the work lies in the 'appreciation,' given by the German General Staff, of the siege as a whole.

"The Japanese artillery," writes the German author, "was not employed according to modern principles. At the commencement no attempt was made to destroy the Russian guns; but the artillery fire was dissipated on the harbour, the town, and the whole of the enemy's positions. Consequently the assaulting columns suffered much from the

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flanking fire of the Russian artillery." The French reviewer points out, however, that it was the Japanese artillery fire that drove the Russian fleet to make its unfortunate sortie on August 10th; and that it was machine gun, not artillery, fire that decimated the Japanese assaulting columns. For these reasons the German criticism seems hardly justified.

The German General Staff despises mining. It is confident that, if the besieger has enough artillery and infantry, mining will be unnecessary. The French reviewer does not agree with this opinion. He points out that the Japanese did not commence mining until after their superiority in infantry and artillery was overwhelming. On the other hand, the Russians, if they had prepared an efficient system of counter-mines, could have arrested the advance of the Japanese saps, and compelled the besiegers to mine through hard rock, thus prolonging the siege.

In spite of the very partial success that attended the Japanese general assaults, the German General Staff is still in favour of this system of attack. In the face of much evidence to the contrary, all the failures at Port Arthur are attributed by it to insufficient artillery preparation. "It may be anticipated therefore," writes the French reviewer, "that in the next war a general assault will be a frequent preliminary to the step-by-step attack. An energetic defence will always compel the besiegers to adopt the slow methods of a regular siege."

DIRIGIBLE BALLOONS.—A continuation of the previous articles. Of historical interest only.

January, 1907.

DIRIGIBLE BALLOONS.—The continuation and conclusion of the previous articles on the subject. As the authors make no mention of any of the balloons that have been constructed since 1903, the treatise is very far from complete.

J. E. E. CRASTER.

REVUE MILITAIRES DES ARMÉES ÉTRANGÈRES.

November and December, 1906.

THE RÔLE OF THE GERMAN FORTRESSES.—Of late years there has been a great increase of permanent fortifications in Germany. This cannot be attributed to any intention on the part of the German General Staff to abandon the offensive. As the result of a careful study of German strategy, the writer has come to the conclusion that the fortresses lately constructed along the German frontier are to fulfil two rôles. Firstly, they will form a screen behind which the mobilization and concentration of the field armies will take place; it will thus be possible to mobilize and concentrate near the frontier without fear of interruption. Secondly, in the event of a war against both Russia and France, the German armies will be numerically inferior to their opponents, and may find it necessary to adopt an offensive defence of the Franco-German frontier; the fortresses will then form strong pivots about which the field armies will manœuvre.

J. E. E. CRASTER.

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RIVISTA DI ARTIGLIERIA E GENIO.

November, 1906.

OPERATIONS AROUND PORT ARTHUR IN 1904.—By Capt. Luigi Giannitrapani.—Twelve years ago, or in November, 1894, during the war between China and Japan, the Japanese army besieging Port Arthur consisted of 18,000 men under the command of Marshal Oyama, with General Nogi in command of a brigade. The defences on the land side were incomplete, and protected only the eastern and southern sides, where the Chinese had 12,000 men. On the 20th November, Oyama gave orders to attack the southern front; the Japanese artillery opened fire against the two redoubts, one of which was blown into the air at 10 o'clock in the morning and was immediately occupied, whilst the other was carried by assault an hour afterwards; and the following day the entire place fell into the hands of the Japanese.

But the operations around Port Arthur ten years afterwards were of a very different character.

We may be able to divide these operations into various periods each having its special characteristics.

From the commencement of hostilities until the end of May the operations were entirely between the fleet and the coast batteries; at the end of May the battle of Nansan, which ended in a victory for the Japanese, definitely closed the communications between the fortress and Kuropatkin's army, and the land operations may then be said to have commenced.

The first period of the latter embraced the months of June and July, and included on the part of the Japanese the conquest of the land between Dalny and Port Arthur, the fighting for the advanced defences held by the Russians, and finally the complete investiture of the fortress.

The second, during the month of August, is characteristic of the attempts to capture the place by heavy infantry attacks which failed against the obstinate resistance of the Russians.

The third includes the months of September and October. Failing in the hope of capturing Port Arthur by direct assault the Japanese commenced regular siege operations, varied by local general assaults which brought about the capture of the advanced works of the place.

Finally, in the fourth and last period, mining was resorted to, and direct attacks from close quarters led to the final capture of the fortress.

COMMENCEMENT OF THE LAND OPERATIONS—BATTLE OF NANSAN.

After the battle of the Yalu, and after the Japanese fleet had established an effective tactical blockade in the waters of Port Arthur, commenced the disembarkation of the troops whose duty it was to isolate the fortress on the land side. The army was under the command of General Oku, and was composed of 3 divisions which disembarked successively without opposition from the Russians on the tract of coast near Pitsevo. About the 6th May the Japanese succeeded in interrupting the railway near

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Pulianten, just after the train had passed which carried the Viceroy Alexieff on his way to Mukden; but on the following days the communications were re-established so far that on the 8th May a train charged with ammunition was able to enter Port Arthur.

The army of General Oku effected its disembarkation, and was concentrated near the isthmus of Kinchow, which is closed in by the well-known hills of Nansan that constituted the true key to Port Arthur. On this position there should have been a fort to prevent the disembarkation, but unfortunately for the Russians it had not been erected.

The position was indeed formidable both by nature and by art, being almost flanked by the sea, and dominating the plain which had to be traversed before a frontal attack could be made. It was occupied by an entire division.

On the 26th May, after an obstinate struggle lasting from dawn to sunset, the Russian position was taken in flank by the fire from the Japanese guns, and was captured.

The Russian troops retired towards Port Arthur, while the Japanese army during the following days seized the positions of Talienwan and Dalny, thus acquiring an excellent base for disembarking their siege material.

On the 2nd June the advanced guards were only 25 kilomètres from Port Arthur, facing the Russians who had occupied and fortified a long line of defences across the Kuantung peninsula, in which they proposed to make as long a stand as possible in order to gain the necessary time for the systematic defence of the fortress.

In the meantime there took place at Dalny the disembarkation of the troops and materiel to complete the besieging army. General Oku's army was moved north against an offensive movement under General Stakelberg with a view to relieving Port Arthur from investment.

ADVANCE OF THE BESIEGING ARMY DURING JUNE AND JULY: DEFENCE MADE BY THE RUSSIANS OF THE GROUND IN FRONT OF THE PLACE.

The Japanese Besieging Army, during the month of June, occupied gradually a long line, about 25 kilomètres from Port Arthur, across the Kuantung peninsula. Thus it covered the railway and the port of Dalny, and with such means of assistance it was able to concentrate quietly the work of collecting materials for the siege. Meanwhile steps were taken to clear the neighbourhood of Dalny of mines, so as to permit of the free ingress of ships.

On the Russian side, General Stösell, on account of the unfavourable condition in which he found the fortress, continued to hold ground as far distant as possible and contested it step by step. He thus achieved the double object of gaining time for the reinforcement of the principal works, by the construction of advanced works in which the place was still deficient, and of weakening his adversary before he came within the zone of action of the forts.

The position taken up with this object by the Russian 4th Division

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after the battle of Nansan consisted of a series of advanced posts, situated from 15 to 20 kilomètres from the fortress, from which it was well able to dominate the Japanese lines; and behind this position there was a line of heights fortified by field entrenchments which barred an advance from the east. The left wing of the position, evidently the most important, was specially strengthened and was furnished with electric search lights.

The two contending lines thus found themselves at a short distance from one another; and combats of advanced posts, in which some of the Russian ships from Port Arthur were also engaged, took place during the whole of June.

On the 26th June, ten days after the battle of Wafangu, the Russians had lost all hope of succour from the north, and the Japanese Siege Corps commenced to advance.

The right wing (1st Division) remained in its position near Antzushan; a central column advanced towards Pantau; and the entire left wing (11th Division) was directed against the front Pantau-Waitoushan-Shuantinshan occupied by the advanced Russian troops. The heights of Pantau were occupied by the Japanese in a comparatively easy manner, but their left wing met with obstinate resistance so that it was only in the evening that it was able to occupy the enemy's positions as far as the heights south of Kienshan.

The advanced Russian troops retired farther south to Laotushan, on the extreme right of the position occupied by the 4th Division, where they threw up field entrenchments.

The Japanese remained on their new front Antzushan-Shuantinshan, where they rested another month until the 26th July. During this period they brought forward their siege material, and awaited the 9th Division and the 1st and 4th (Kobi) Reserve Brigades which were disembarked in succession. But in the meantime they had to suffer a vigorous counter-attack from the Russians.

December, 1906.

OPERATIONS AROUND PORT ARTHUR IN 1904.—By Capt. Luigi Giannitrapani, Captain of Artillery.

COAST DEFENCES.

We have seen that in the operations round Port Arthur the small efficacy of the fire of ships against coast batteries has been fully confirmed. The losses in the Russian batteries were slight, both in matériel and in men. A Russian artillery officer, Judenic, who took part in the defence of the place, relates, in an article published in the *Eenzhenernee Zhoornal* of May last, that the masses of cement in the coast batteries were protected with sheet iron against splinters caused by the enemy's projectiles, but that such splinters did not really occur and the cement when struck resisted in the best possible manner. The sheets of iron, however, formed a good protection against the flames produced by the fire of the mortars.

The artillery duel between the ships and the coast batteries almost always took place at a distance of from 6 to 8 kilomètres. Considering

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the small results from the fire of the ships, it might be conjectured that such fire would be more efficacious if the ships approached nearer; but this is an erroneous hypothesis, since by diminishing the distance the angle of descent is also diminished considerably, and this decreases the vulnerability of the coast batteries, at the same time increasing the perforating power of the projectiles thrown from these batteries against the ships.

The effects of the bombardments of the Japanese ships against the city, the arsenal, and the Russian ships in the inner bay did not produce heavy material losses, although causing a certain amount of disorganization and panic, especially among the civil population. The action of the Japanese fleet, facilitated in a measure by the want of batteries on the Laotishan promontory, was brought to perfection by the employment of indirect fire, controlled by wireless telegraphy from an observing cruiser stationed at a distance. This became a real danger particularly to a place not exclusively military but containing also a civil population. The panic produced in Port Arthur was limited in its consequences owing to the civil population being small, so that grave disturbances on the part of the inhabitants, who were unable to influence the conduct of the defences, were restrained.

OBSTACLES, SEARCH LIGHTS, AND MINOR ARMAMENTS.

The operations outside Port Arthur from June to December, 1904, present many features for study. Among these may especially be noted the employment on a vast scale of certain technical measures, prearranged but improvised, which give to this siege a particular character.

Special mention may be made of barbed wire, an accessory means of defence certainly not new, but which by its very extensive employment by the Russians contributed greatly to retard the assaults of the Japanese infantry who had commenced to feel the nature of the resistance offered at the position of Nanshan. The wire entanglements were placed in all the works and trenches, and even the heavy shell fire did not succeed in destroying them. The Japanese tried several methods of overcoming these obstacles. At first they distributed scissors of a special pattern, in great numbers, and sent detachments of sappers, crawling along one by one, who, lying down near the wire, endeavoured to cut it; but frequently the wire was so thick that it was not possible to cut it by this means, and the Japanese officers reported that sometimes the men were so enraged at their useless efforts that they threw down the scissors and tried to break the wire with their hands and teeth, twisting and biting it until they succeeded in forcing a passage. Afterwards the Japanese tried to break down the entanglements altogether by cutting the posts that supported the wire; but this again failed, owing to the men being so much exposed to the enemy's fire. They then concocted a plan of covering from the enemy's view the men employed in breaking the obstacle. They filled long bamboo canes with black powder which created a dense smoke; the men carrying the canes stretched themselves on the ground close to the obstacle, and, setting fire to the ends of the canes, pushed them

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into the entanglement; the several explosions broke and destroyed the wire. The canes were also charged with guncotton and the black powder, setting fire to the guncotton, exploded the charges at the same time.

The Russians also made use of metallic wire charged with a current of 500 volts produced from a dynamo situated inside a fort. But this system also failed in its purpose, because the Japanese easily cut the wire with large pincers furnished with insulators.

Sometimes the Japanese, in full daylight, advanced against the obstacles protected by big shields. The shield was suspended from the shoulders of a man who advanced on his knees, thus progressing slowly; the bullets did not actually strike the man, but sometimes powerful shocks caused him to fall, and he could only recover himself with much difficulty. Afterwards lighter and more manageable shields were tried.

Among the various methods used for defence from night attacks the Russians, at the commencement of the siege, made use of electric search lights. These discovered the Japanese infantry advancing to the assault, thus causing them confusion, while at the same time the quick-firing guns and pompoms poured on the troops thus exposed a shower of shells. The correspondents who were present at the siege report that the beams from these lights were so powerful as to light up every part of the ground as though it was daylight. The Japanese seemed unable to make much advance under these search lights, which they considered one of the most formidable of the enemy's methods of defence. Much of the time of the advance was taken up in seeking for inequalities of the ground, between which the implacable rays of the search lights could not find them out, but after August they appear to have abandoned the great night attacks which characterised the first period of the siege.

Another method of the Russians for lighting up the ground was the employment of bomb stars. These gave a shower of white phosphoric light which completely illuminated all the ground below. The light coming from a height, and being of considerable intensity, left no spots of shadow, and no one could move in the illuminated zone without being discovered.

Mitrailleuses were also largely used by the Russians and with great success. These weapons could be carried by two men, their small size rendering their discovery difficult; the Japanese suffered from the terrible effects of their projectiles, and the Russians were able easily to repel the assaults of the enemy's infantry. At night the mitrailleuses were used with great effect with the assistance of the search lights, which discovered and confused the enemy.

The quick-firing guns of small calibre, with which the Russians were largely provided, had great moral as well as material effects on the Japanese.

That ancient weapon, the hand grenade, which had been relegated to historic records, was again brought prominently forward in this war at the beginning of the XXth Century, and we find it in use by both Russians and Japanese in the field operations during the siege. The

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soldiers had great faith in these projectiles, which they threw by hand by means of a kind of catapult. On the Japanese side the grenades were fired by means of very light mortars of wood, bound with bamboos, which were carried by two men following the assaulting columns. They were carried in baskets of willow twigs.

According to reports furnished by a Russian Engineer officer who took part in the defence of Port Arthur, the Japanese made use of a special kind of hand bomb, charged with prisms of melenite, which had a very powerful effect.

The Russians also made use of some large land torpedoes—some of great weight, as much as 250 k.g.—with slow matches lasting from 1 to 2 minutes, which they threw against the enemy, causing great panic and heavy losses. According to Japanese sources of information the Russians also employed naval torpedoes for their land defences.

Terrestrial mines, fired automatically by electricity, were also largely used during the siege. But according to Russian reports only 1·80 per 100 of these were successful, chiefly owing to the wires being broken by the enemy.

TRIALS OF THE HOLMGREN EXPLOSIVES.—Capt. Andrea Holmgren of the Swiss artillery has furnished the following information regarding the experiments carried out on the 23rd August, 1906, on an explosive of his invention. Trials were made with projectiles weighing 41 k.g., charged with 3·5 k.g. of the Holmgren explosive. Against an entrenchment at a distance of 3,900 m. the projectiles made cavities in the ground varying from ·50 to 1·20 m. in depth, and from 2 to 3·5 m. in diameter and breaking 20 x 25 c.m. beams which formed a covering for the trenches.

It was ascertained that projectiles charged with this explosive produced the same destructive effects as the explosives now generally used, while Holmgren's explosive has the advantage that in event of the bursting of the shell before it leaves the mortar no damage is caused to the gunners: this at least is stated by the author to have been demonstrated at the trials. The trials also proved that no splinters were thrown in a backward direction, so that no injury would be caused either to the gunners or to the guns or mortars in the case of the projectiles bursting immediately after leaving the mouth of the mortars.

Some shrapnel were fired with a quantity of such an explosive, but specially adapted to create an abundant smoke at the moment of bursting. They were fired from field guns against a target at a distance of 1,000 m. The shrapnel produced dense clouds of smoke, which in a few minutes concealed the target like a thick cloud, and in action it would have been possible to advance against the firing line without being discovered.

No communication has been made with regard to the composition of this explosive.

EDWARD T. THACKERAY.

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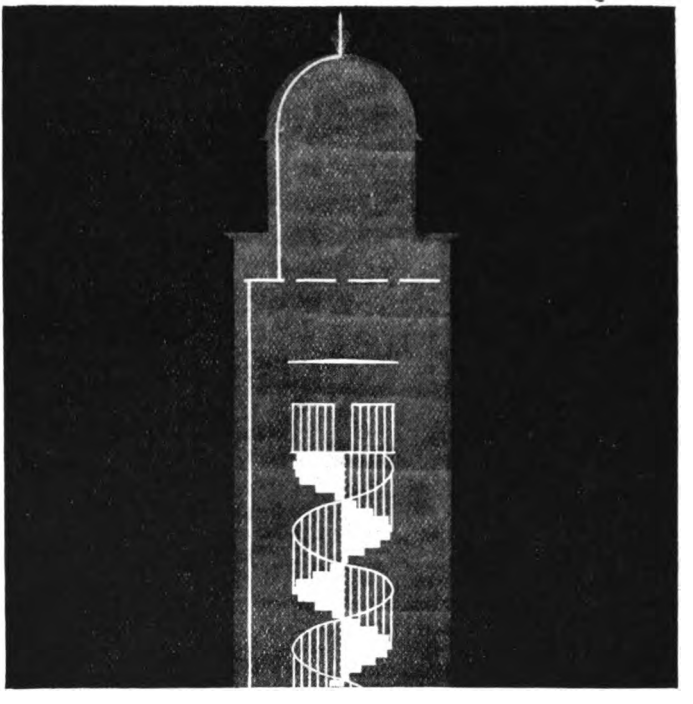

FIG. 6.—A Tower at Westminster Cathedral.

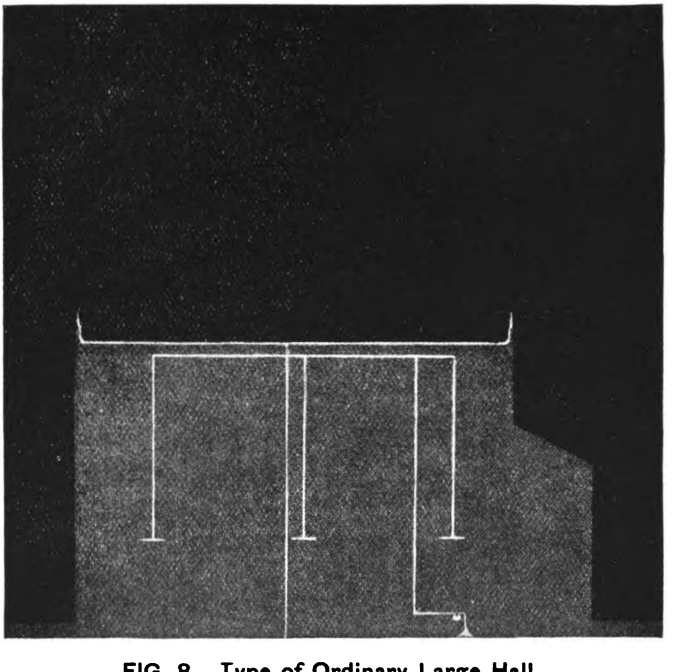

FIG. 8.—Type of Ordinary Large Hall.

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STAFF COLLEGE, AUGUST, 1906.

The following Officers, whose names are arranged in regimental order, were successful from us at the recent Competitive Examination for admission to the Staff College.

Capt. C. Evans, R.F.A.
,, G. C. Merrick, D.S.O., R.G.A.
,, W. H. Moore, D.S.O., R.G.A.
,, J. P. Mackesy, R.E.
,, B. W. B. Bowdler, R.E.
,, F. D. Farquhar, D.S.O., Coldstream Guards.
*Capt. R. G. Parker, Rl. Lancaster Regt.
Capt. G. N. T. Smyth-Osbourne, Devonshire Regt.
Capt. V. H. M. de la Fontaine, East Surrey Regt.
Capt. and Bt. Major F. R. Hicks, Hampshire Regt.
Capt. H. S. Williams, Dorsetshire Regt.
,, B. D. L. G. Anley, D.S.O., Essex Regt.
Capt. R. S. Hamilton-Grace, Durham Light Infantry.
*Capt. H. F. Baillie, Seaforth Highlanders.
,, P. S. Allen, Gordon Highlanders.
,, J. K. Cochrane, Leinster Regt.
,, R. L. Ricketts, Indian Army.
,, W. K. Bourne, Indian Army.
,, F. W. Lumsden, R.M.A.

The following Officers received nominations:—

Capt. H. C. Bickford, 6th Dragoon Guards.
Capt. C. J. C. Grant, Coldstream Guards.
Capt. W. D. Wright, V.C., Royal West Surrey Regt.
Capt. C. H. Harington, D.S.O., Liverpool Regt.
Capt. H. Wake, D.S.O., King's Royal Rifle Corps.
Capt. and Bt. Major N. J. G. Cameron, Cameron Highlanders.
Capt. G. P. Grant, D.S.O., Indian Army.

SANDHURST, JUNE, 1906.

FIRST	A. G. Armstrong 5,541	129th	R. P. T. Ffrench..... 3,827
48th	H. G. Gauntlet 4,515	181st	C. W. Molony..... 3,445
67th	D. Macdonald..... 4,299	186th	P. J. I. Synnott 3,386
89th	W. G. Bagot-Chester..... 4,115	190th	R. M. Aylmer 3,339
90th	A. G. Ottley 4,109	197th	O. Gough..... 3,262
93rd	A. P. Williams-Freeman 4,094	201st	P. W. J. A. Stomm 3,151
115th	D. M. Black 3,940	213th	B. W. Molony 2,881
125th	W. J. King-King 3,846		

WOOLWICH, JUNE, 1906.

31st ... ... J. S. Barkworth 6,483

DECEMBER, 1905.

SECOND	H. G. MacGeorge 7,196	16th	R. Crofton 6,330
FOURTH	G. Walton 7,046	45th	D. Stephenson 5,899
FIFTH	H. A. Cox 6,967	54th	J. Kennedy 5,711

This was the First Examination under the new regulations, and our pupils secured THREE out of the first FIVE places.

MILITIA COMPETITIVE, MARCH, 1906.

A. E. Hardy	2,304	W. F. Anderson	1,947
N. H. Hutcheson	2,105	D. C. Robinson	1,879
F. D. Frost*	1,949	F. A. Bowring	1,876

*Read partly at the Army College, Aldershot.

ARMY QUALIFYING, 1906.

Nineteen passed.

Special Arrangements have been made for the Army Qualifying in next Examination.

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THE ROYAL ENGINEERS JOURNAL.

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Notes on Steel Concrete, by Major J. Winn, R.E., Assoc. Inst. C.E. 2nd Edition	1904	2 6
Notes for Officers Proceeding to India. Compiled by Major A. T. Moore, R.E. (Part I. Outfit, Servants, Amusements, Health, Hints for Ladies, etc.; Part II. Physical Features, Administration, Native Army, History, Languages, Castes, Religions, etc.; Appendix. Shooting Hints)	1904	2 6
Detailed History of the Railways in the South African War, 1899—1902. 2 vols. (Vol. I. Organisation, Military Control, Working and Repair of Cape and Natal Government Railways; Management, Engineering and other Departments of Imperial Military Railways; Railway Pioneer Regiment; Organisation, Equipment and Use of Armoured Trains; Army Labour Depôts; pp. xli. and 275. Vol. II. 61 Photos and 93 Drawings) ..... Folio	1904	42 0
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PREVENTION OF CONDENSATION IN UNDERGROUND MAGAZINES.

By Lt.-Col. B. R. Ward, R.E.

Engineers in charge of Coast Defences are constantly being confronted by the problem of how best to remedy dampness in underground magazines. Hollow interior walls, dry packing laid against outside walls, and an asphalte covering to the roof—all necessary in their way as a protection against percolation—are, however, of no use whatever against the condensation of aqueous vapour in the air on the walls of the magazine.

The latest attempt to cope with the evil of condensation at Halifax, Nova Scotia, has been by means of specially constructed large ventilators which allow of a horizontal draught through the magazine.

This system was introduced by Colonel W. L. Marshall, Corps of Engineers, United States Army. Extracts from his report to the Chief of Engineers were published in the September, 1905, issue of this *Journal.*

Before describing the system as applied to the forts at Halifax it will be of interest to follow the history of previous attempts to cope with dampness due to condensation.

In Article 491, *Ordnance Regulations*, 1855, it was ordered that magazines should be opened for purposes of ventilation "every fine day."

The result of this practice in warm still weather was that the condensation of the vapour of water on the interior walls of magazines was unnecessarily increased; for warm air coming in contact with the cooler walls of the magazine occupies a smaller cubic content than when outside, and moisture that is held in suspension at the higher temperature is deposited as dew on the walls and floor of the magazine at the lower temperature.

Accordingly an *I.G.F.'s Circular*, Gen. No. 5/5252, D.W. No. 178, dated 26th August, 1870, adverted to in Clause 130 of *Army Circulars*, 1870, was drawn up and sent round from the War Office in order to explain the action of condensation and the principles that should govern the ventilation of magazines.

By following these instructions, and opening the doors of magazines at those times only when the dew-point of the external air was lower than the temperature of the interior of the building, it was hoped that the evil effects of condensation would be largely eliminated by natural ventilation alone.

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These instructions have since been slightly modified, the most recent instructions being those contained in the *Regulations for Care and Preservation of War Material and for Magazines*, 1902, Section V., "Ventilating," paras. 102—123.

In countries where the range of temperature is not excessive, a system of natural ventilation based on the above instructions may possibly be successful in avoiding an undue amount of condensation.

In Nova Scotia, however, where the frost penetrates as far as 6 feet into the ground, and consequently the interior walls of underground magazines retain a low temperature far into the summer, the application of the foregoing system has not proved a success. In addition to this, the prevailing southerly winds are heavily laden with moisture.

Matters at Halifax accordingly appear to have gone from bad to worse, as might have been expected; and complaints were continually put forward by the local Ordnance officers as to the damp condition of magazines, until early in the eighties experiments were made to supplement natural ventilation by artificial heating.

The first means tried for artificial heating was hot water. This method is largely employed in heating private dwellings in Canada. At the lowest point of the system is a boiler from which hot water is kept circulating through a system of pipes arranged in the interior of the building. The objection to hot-water heating when used in private dwelling houses—namely, the excessive dryness of the air caused by it—was a strong point in its favour when applied to magazines; and as a matter of fact this system answered admirably.

Before the experiment was tried considerable doubt existed as to whether this system would prove a success. It was feared that, in the case of magazines with walls in actual contact with the cold earth outside, the walls would not be sufficiently heated to prevent the condensation of moisture. The success of the system shows, however; that the warmed air, penetrating the concrete or brickwork of the walls, raises the temperature sufficiently to prevent condensation.

The first hot-water heating apparatus was installed in an underground magazine at Halifax in 1885, and a record of observations was taken from August, 1885, to August, 1886. For the first 17 days the magazine was reported as damp; from that time onwards it appears to have been dry. Similar installations have since been made in at least three other magazines at Halifax.

When in working order this system is absolutely satisfactory. Considerable expense has, however, been incurred in upkeep, owing to the frequent bursting of the pipes. This has usually occurred through carelessness in allowing the fire to go out in very cold weather, the result being the freezing of water in the pipes and boilers.

This disadvantage of hot water led to further experiments in

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heating systems. During the winter of 1904–05 a trial was made at the Lumber Yard of a hot-air furnace for forcing warmed and dried air into a magazine. The success of this trial warranted the erection of a hot-air furnace in one of the forts in the summer of 1905. The result may be said to have justified expectations.

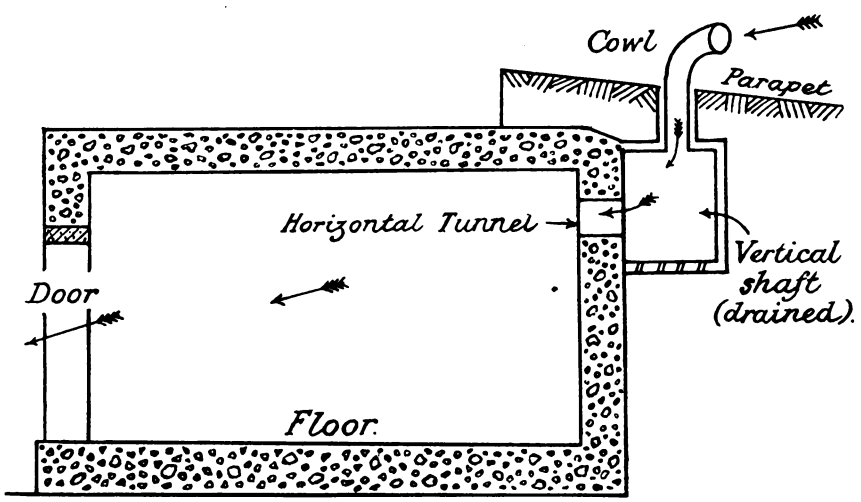
The hot-air system did not keep the magazine so thoroughly dry as the hot-water system; but the magazine was sufficiently dry for practical purposes, and the hot-air system possessed the following advantages over the other:—

(*a*). A cheaper installation, and less cost in maintenance.
(*b*). No risk of damage by frost.
(*c*). No skilled labour required for working.

It may here be incidentally mentioned that artificial heating for prevention of condensation is only required in the summer time; the fact that the temperature of a magazine in winter is higher than that of the outside air being sufficient to account for the absence of condensation during the winter months. The risk of damage by frost—and such damage has taken place at Halifax on several occasions—should therefore never occur, if the fire is only kept lighted during the summer.

The real disadvantage of either hot water or hot air is the expense of installation, upkeep, and fuel. A further set of experiments was therefore carried out last summer, in order to try the system of natural ventilation devised by Colonel Marshall.

The main idea underlying Colonel Marshall's system is that a draught of air should be passed right through the magazine. This can be done by piercing the wall of a magazine with a horizontal tunnel, some two feet in diameter, connecting with a vertical shaft sunk in the parapet just outside the magazine.



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A removable cowl, such as is used on board-ship, is placed over this vertical shaft, and may be turned in the direction of the wind, when a current of air is forced in the direction shown by the arrows.

If the direction of the wind is such as to pass through the magazine more naturally in the opposite direction—*i.e.* from the door to the vertical shaft—the cowl should be removed. The wind passing over the vertical shaft extracts the air and causes a draught from the magazine through the vertical shaft to the outside.

From the experiments carried out during the summer of 1906, at No. 1 Magazine, Fort McNab, Halifax, it would appear that good results attend this system of through ventilation if put in operation with the wind anywhere between north-west and north-east. As soon as the wind gets south of this sector the magazine, including all ventilators, shell-lifts, cartridge-lifts, etc., should at once be closed.

The system just described involves a departure from existing regulations and designs in the following particulars :—

(*a*). No observations of dew-point are required.
(*b*). Small vertical shafts surmounted by rotating cowls are superseded by a horizontal tunnel of considerable section leading into a vertical shaft outside the magazine.
(*c*). Means must be adopted for sealing all openings to the magazine in damp or warm still weather.

Colonel Marshall's report, referred to above, is of special interest to officers engaged in the design or construction of magazines.

It shows that good results have actually followed the application of the "through draught" system in two of the New York forts. It explains clearly why small vertical shafts, such as are provided in our existing magazines and type drawings, are so ineffective. These small openings increase rather than reduce condensation, a similar system of pipes being actually in use near Chicago for irrigation purposes.

It also emphasizes the difficulty of applying the "dew-point" regulations, and draws attention to the futility of the theory that magazines should be opened only when the outside air is at a lower temperature than the air in the magazine. The true aim, on the contrary, should be to regulate a "through draught" in the magazine, so that the temperature of the walls should be kept as high as it is possible to keep them without risk of condensation.

Colonel Marshall's system is a revolutionary one; and if experience proves it to be successful in practice, it will necessitate considerable changes in our type drawings of magazines and also in the "ventilation" section of our Magazine Regulations. To quote from the words of his report—"All existing methods and rules should be cast aside, at least so far as to allow methods of ventilation to be provided on the broad principle that air when not saturated will absorb and

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remove moisture at any temperature ; and if passed over objects, masses, or walls in sufficient volumes will soon reduce these walls to the same temperature as the air."

The Canadian Government has approved of the application of Colonel Marshall's system to four of the Halifax forts. A decisive test as to the value of the system will probably be possible during the summer of 1907.

The following regulations have been locally approved as a guide to the N.C. Officers in the various forts who will have charge of the experiment.

MAGAZINE VENTILATION.

(*Colonel Marshall's System*).

RULES FOR OPENING AND CLOSING OF MAGAZINES.

MAGAZINES TO BE CLOSED when the following conditions hold :—

1. Generally throughout the winter, except on days when there is a brisk breeze and clear weather, and the temperature is well above the mean annual temperature,—say 45° Fahr., the mean annual temperature of Halifax being 42° Fahr.
2. When it is still or calm weather.
3. When the air is filled with fog or mist.
4. Generally at night and after 2 p.m.

MAGAZINES TO BE OPEN under the following conditions :—

Whenever there is a wind exceeding 5 miles an hour and the temperature is above mean annual temperature (42° Fahr.) with no fog, mist, or rain accompanying.

N.B.—During the period April to September inclusive Magazines should not be opened up unless the direction of the wind is somewhere between North-West and North-East.

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A Personal Experience of
*THE EARTHQUAKE IN JAMAICA.**
14th JANUARY, 1907.

By Col. E. D. Malcolm of Poltalloch, c.b., late R.E.

After much arrangement there was a great agricultural conference in Jamaica, and the lords of the cotton business—growers, buyers, brokers, shippers, spinners, with men of science of many sorts, some coming direct from England, others from various West Indian Islands—arrived safely by the s.s. *Port Kingston* on Friday, January 11th, 1907. Various trips had been arranged for the Friday and Saturday, and on Monday the conference began.

I had been expecting a party to arrive on Friday to view the cattle-grazing part of the country in the west, but the railway journey of some 80 miles proved to be too serious a matter, though an inhabitant could have assured the delegates that every mile would have furnished fresh delight. Be that as it may, I had arranged to go to Kingston on Monday the 14th, partly to attend the conference, partly to attend a big ball which the Governor was giving on the 16th, but chiefly to take my passage home on the 17th.

The 14th was a lovely day, beautiful even among the glorious days of the Jamaican winter, and I, with my son and man-servant, made the journey into Kingston in the greatest comfort. On arrival I was met by a young coloured clerk of a big Kingston firm, who took over my heavy luggage and accompanied my man-servant to the wharf, while my son and I drove off to the house of the Chief Justice of the island, who had kindly invited us to stay with him.

Just as we got to the outskirts of the town, we heard a violent rumbling behind us, as of a tramcar on the rampage, and wondered why our coachman did not get out of the way. Then I noticed two or three bricks roll quietly on to the road, and immediately, with three loud explosions, the top of a brick-built church tower, opposite to which we were, fell down, but nothing touched us. Even then, we did not at once realise what had happened, for we had felt no shock—an experience which, I subsequently learned, was common to many who were in carriages at the moment. Nothing very serious seemed to have happened, except the fall of the tower, which we mentally ascribed to unskilful workmanship; but as we continued

* A letter to "The Scotsman" written on board the s.s. *Port Kingston* on 31st January, 1907.

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our drive we soon began to see marks on every side which loudly proclaimed "Earthquake."

For some time it seemed as if the damage was slight, but on arriving at our destination we found our host's house in ruins; the back, front, and one side wall were down; the roof, deprived of support, was touching the ground; and one unfortunate young lady had been hurt, though, I hope, not seriously. Our hostess was naturally most anxious about her husband, who was holding Court in the town, and lost not a moment in starting off in her carriage to search for him. To her unspeakable relief, she met him a short way from home, and heard from his own lips that, although the wall of his Court-house had fallen out, he himself was absolutely unhurt.

I now determined to return to the harbour, and, on the road, was saddened to see the smoke of big fires, which, working with the breeze off the land, rapidly extended towards the sea. When nearing the business part of the town, we were assured that the streets were impassable; but nevertheless, though not without considerable difficulty, I managed to reach the ship, and found it transformed into a vast hospital, from which I gazed upon the most appalling fire I have ever witnessed. For two whole days the conflagration raged without apparent slackening, and had not completely burned itself out when the ship left on Friday, the 18th, at 4 p.m.

Nothing could, I think, exceed the sadness of Tuesday and the following days. The terrible uncertainty as to who had been taken and who left hung like a pall over everything. Wealthy men found their all destroyed; business premises, books, etc., burned by the fire, even when the buildings had withstood the earthquake; their private houses levelled to the ground; no shelter even for those members of their families whom they had been able to collect. Husbands were seeking in vain for their wives, and wives for husbands; mothers for children, and so on. Why dwell on all this.

I can only say that the agony of those days cannot be exaggerated, any more than can the miraculousness of many escapes. The large hotel of Myrtle Bank was ruined. The greater part came to the ground at once, and what was left standing was brought down by the subsequent shock. The Constant Springs Hotel, though generally standing, is split from top to bottom in many places. The King's House, the residence of the Governor, was made unsafe to live in, so that all his large party had to camp out in the garden. The barracks at Up-Park Camp were totally destroyed. I mention these few cases to convey an idea of what the damage was among other less solidly built constructions.

Tidings came also of the further subsidence of Port Royal, which we were able to verify, on steaming out, by seeing a small grove of cocoanuts with the salt water half way up their stems. Then we heard of most serious damage to Newcastle, the barracks for white

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troops up in the hills behind Kingston. It was soon found, too, that the whole telegraph system of the city, and much of the island, was disorganised; the three submarine cables to the outer world were broken, apparently about three miles out to sea.

To keep order—for I may say that looting began very early—there was only a small force from the West Indian Regiments and the police, a force which, as we all know, is never more than strong enough to cope with ordinary conditions. I can assure you that blessings—or the other thing—many and strong were heaped upon those who had removed the naval and military forces from the island. Fortunately the American Navy in the shape of two cruisers and a torpedo-boat put in an appearance, bringing prompt help and sympathy from the American people, which was greatly appreciated. Still all wanted to know "Where are our own people; where, at least, that ship that was to be at hand at a moment's notice?" She was expected on Friday night, but had not appeared at 4 p.m. of that day, when the *Port Kingston* left, a whole day after her advertised time. In the meantime a body of over sixty men had to my own knowledge to be landed from our ship no less than three times to help to keep order.

The effects of the earthquake reached to my own place, some 80 miles from Kingston, where the church wall was cracked and the house of a neighbour was destroyed. The telegraph has already brought to this country more details than it was possible for us to know before we left the island. The steamer, by the way, had a narrow escape. My servant, who was on the wharf, describes the feeling as a rough shaking in all directions at once, and then three heavy kicks, during which the steamer reared up into the air. Luckily she did not hit the wharf in falling back, or the consequences might have been most serious.

It feels like an impertinence to praise the Governor, and the conduct of the officers of the *Port Kingston*, who worked, oh so willingly! without rest until absolutely exhausted, or indeed of the wounded, who next day were got off the ship into a hospital improvised out of a goods shed and whose courage and calmness were on the whole very remarkable. I saw the Governor on board the *Port Kingston* at 5 a.m. on Tuesday morning, and I have since heard that, though practically without sleep for forty-eight hours, he everywhere set to all a golden example of coolness and courage.

I am sure that while I write large subscriptions are being collected for the sufferers in this calamity. I earnestly hope, however, that the relief will not be confined to Kingston alone, as I know that damage was done far outside, and I earnestly plead the cause of the ruined rich. I hope and trust that it will be remembered that the rich, who with hardly an exception have seen their all swept away, have done their best to give work to the poor. If they can be helped by

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moderate loans or gifts to make a fresh start; their character and energy will enable them to pull round in a short time ; but the haberdasher or dry-goods merchant, for instance, must have some place in which to bestow his wares before he can import them from outside. Two well-to-do men, with increasing businesses, who are returning on board this steamer, ruined, have told me their stories, which, after all, are only typical of many others. One, who had just enlarged his premises, and had installed the newest machinery, awoke that morning with every hope of entering upon a period of increased prosperity. The other has a wife and large family, who are now coming home with free passages, destitute of everything except what they stand up in, while a poor child has both legs broken. Each of these men employed quite a large number of intelligent blacks, who were absolutely dependent upon their employers. Surely the best way to help the blacks is to help the masters, who had their all destroyed in six short seconds.

I must add that, before I left Jamaica, I received an assurance that my own property had escaped without damage of any kind, so that I cannot be accused of pleading for myself. All I wish to do is to state the case for a certain class of sufferers which is occasionally apt to be overlooked.

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DOUBLE ENTRY FOR ORDINARY COMPANY PAY ACCOUNTS.

By MAJOR D. BRADY, R.E.

IT is suggested that the following method of keeping Company Accounts would be more satisfactory than that now recognized.

In the examples the entries have been shortened to save room. In actual practice a sufficient description of each transaction should follow the formal words.

Numbers and letters have been used as references, instead of dates, so as to make the examples easy to follow.

(1). The Captain receives a cheque for the estimated requirements of the month, say £300. He at once pays it into his bank, and enters it thus—

In the Government a/c—
Cr. by Bank £300
In the Bank a/c—
Dr. to Govt. (per Chief Cashier) £300

(2). Week by week he cashes a cheque for pay-day, and enters it thus—

In the Bank a/c—
Cr. by Cash £60
In the Cash a/c—
Dr. to Bank..... £60

(3). Week by week he pays the Company. The Government is liable for the sums he pays, so the Government may be debited at once, instead of first debiting the men and then crediting them and debiting the Government. Thus—

In the Cash a/c—
Cr. by Govt. (paid to Co.)..... £60
In the Govt. a/c—
Dr. to Cash £60

(4). A certain sum is stopped from the men for their fund, known as the Company (Consolidated Stoppage) Fund (which will be referred to here as the Co. C.F.). The Government is liable for this to the men, and the men to the fund, so the Government may be debited at once as in the last item.

In the Govt. a/c—
Dr. to Co. C.F. £21
In the Co. C.F. a/c—
Cr. by Govt. £21

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(5 and 6). At the end of the month the Government becomes liable to the Captain and others for various small sums for contingent allowance, postage, marking clothing, etc.; and these sums are paid to those entitled to them.

(5). But first a cheque must be cashed

As before in Bank a/c—
Cr. by Cash £1 5 0
In Cash a/c—
Dr. to Bank £1 5 0

(6). The cheque having been entered, the entries now are—

In the Cash a/c—
Cr. by Govt. (detail of payments in 1st column) £1 5 0
In the Govt. a/c—
Dr. to Cash (part 3 payments) £1 5 0

(7). There may be some sums due to the Government from the Co. C.F.—

In the Govt. a/c—
Cr. by Co. C.F. ..... 15s. 6d.
In the Co. C.F.—
Dr. to Govt. (damages) ..... 15s. 6d.

(8). There are some bills against individuals in the pay list, and the entries are—

In the Govt. a/c—
Dr. to Cash (part 2 payments) ..... 5s. 5½d.
In the Cash a/c—
Cr. by Govt. (shoemaker) ..... 5s. 5½d.

(9). The Captain of the Company draws cheques to pay the various bills payable from the Co. C.F.—

In the Bank a/c—
Cr. by Co. C.F. (names of payees)...Total £19 10 0
In the Co. C.F. a/c—
Dr. to Bank (particulars of bills, washing, groceries, etc.) .....Total £19 10 0

(10). The sale of refuse, or a grant from the canteen, or a donation or subscription, may give the Co. C.F. £3—

In the Co. C.F. a/c—
Cr. by Cash (particulars) £3 0 0
In the Cash a/c—
Dr. to Co. C.F. £3 0 0

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If all these entries are traced in the ledger, and the accounts are balanced, the balances closing the accounts will be found to be—

BALANCE SHEET.

Liabilities.	£	s.	d.	Assets.	£	s.	d.
To Government	3	5	0½	By Bank	4	5	0
„ Co. C.F.	3	14	6	„ Cash and stamps...	2	14	6½
	£6	19	6½		£6	19	6½

These Balances, transferred to the opposite side, form the opening balances for the accounts of the next month.

But the Military Accountant, when he audits the accounts, may find something to correct.

(X). He observes that a man, by name Jones, who has left the company, has been overpaid 1s.

(Y). That Barrack damages have been overcast 6d.

(Z). And he disallows a half-penny, as a fraction.

He accordingly says that the Government credit balance is £3 5s. 7d., not £3 5s. 0½d. as shown.

(X). The Captain must collect 1s. from Jones, or from himself if he cannot get it from Jones, and enter it thus—

In the Govt. a/c—
Cr. by Cash (Obsn.) ..... 1s.
In the Cash a/c—
Dr. to Govt. ..... 1s.

(Y). The Captain must re-credit the fund from which the damage came, and debit Government—

In the Co. C.F. a/c—
Cr. by Govt. ..... 6d.
In the Govt. a/c—
Dr. to Co. C.F. (Obsn.) ..... 6d.

(Z). The disallowed fraction the Captain must make good himself (next month he may be allowed a fraction)—

In the Govt. a/c—
Cr. by Cash (Obsn.) ..... 0½d.
In the Cash a/c—
Dr. to Govt..... 0½d.

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Now, on balancing again, the Balances will be—

BALANCE SHEET.

Liabilities.	£	s.	d.	Assets.	£	s.	d.
To Government	3	5	7	By Bank	4	5	0
„ Co. C.F.....	3	15	0	„ Cash and stamps ...	2	15	7
	£7	0	7		£7	0	7

These are the correct balances for the new accounts.

It is not sufficient merely to correct faulty balances; the accounts will be useless unless the method of the correction is shown.

Each account should be kept on a separate page of the Ledger.

It will be observed that the Government Account is the Pay List statement of Receipts and Expenditure *reversed*.

The Bank and Cash Accounts are separated. There is no good reason for keeping them mixed up. Separate, each has a spare money column to use for details; nothing but the totals need go into the main column, and they will be found much easier to check and add up.

The Company (Consolidated Stoppage) Fund is kept as everyone keeps it at present.

The Balance Sheet will be found to correspond exactly to the statement in the Pay List that goes by the extraordinary name of "Cash Reconciliation Statement."

Accounts kept in the manner explained will be found very easy to keep. Double entries are necessary under the existing system between Bank, Cash, and the Company Fund; but they are made without method. The only new account proposed is the Government one; this *must* be worked out for the Pay List, and it is better to do it in the ledger than on loose scraps of paper.

If the Captain of a Company keeps his accounts by double entry he *cannot* pay or receive anything without knowing the proper person to debit or credit.

This is common commercial book-keeping, the result of the business experience of many centuries. There is nothing new or experimental about it.

If anyone should care to read it up, he could not get a clearer or a better book than Hamilton & Ball's *Book-keeping*, 2s.

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LEDGER.

Folio 1.

CASH.

Dr. *Cr.*

		£	s.	d.			£	s.	d.	£	s.	d.
2	To Bank	60	0	0	3	By Govt. (paid to Co.) 1st week	60	0	0			
,,	,, ,,	70	0	0	,,	,, ,, ,, ,, 2nd ,,	70	0	0			
,,	,, ,,	70	0	0	,,	,, ,, ,, ,, 3rd ,,	70	0	0			
,,	,, ,,	75	0	0	,,	,, ,, ,, ,, 4th ,,	75	0	0	275	0	0
5	,, ,,	1	5	0	6	,, ,, (detail here)				1	5	0
10	,, Co. C.F.	3	0	0	8	,, ,, (shoemaker)					5	5½
						Closing Balance				2	14	6½
						(Cash, £2 10s. 4d.; Stamps, 4s. 2½d.)						
		279	5	0						279	5	0
	To Opening Balance	2	14	6½								
X	,, Govt. (Obsn.)		1	0								
Z	,, ,, ,,			0½		By Closing Balance				2	15	7
		2	15	7						2	15	7
	To Opening Balance	2	5	7								

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Folio 17.

BANK.

Dr. *Cr.*

		£	s.	d.			£	s.	d.
1	To Govt. (per Chief Cashier)	300	0	0	2	By Cash	60	0	0
					,,	,, ,,	70	0	0
					,,	,, ,,	70	0	0
					,,	,, ,,	75	0	0
					5	,, ,,	1	5	0
					9	,, Co. C.F. (details here)	19	10	0
						Closing Balance	4	5	0
		300	0	0			300	0	0
	To Opening Balance	4	5	0					

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Folio 33.

GOVERNMENT.

Dr. *Cr.*

		£	s.	d.			£	s.	d.
3	To Cash (payments to Co.)	275	0	0	1	By Bank	300	0	0
4	„ Co. C.F.	21	0	0	7	„ Co. C.F.		15	6
6	„ Cash (part 3 payments)	1	5	0					
8	„ „ („ 2 „)		5	5½					
	Closing Balance	3	5	0½					
		300	15	6			300	15	6
Y	To Co. C.F. (Obsn.)			6		By Opening Balance	3	5	0½
					X	„ Cash (Obsn.)		1	0
	Closing Balance	3	5	7	Z	„ „ „			0½
		3	6	1			3	6	1
						By Opening Balance	3	5	7

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Folio 49.

COMPANY CONSOLIDATED FUND.

Dr. *Cr.*

		£	s.	d.			£	s.	d.
7	To Govt. (Barrack Damages)		5	6	4	By Govt. (from Pay List)	21	0	0
9	„ Bank (particulars)	19	10	0	10	„ Cash (particulars)	3	0	0
	Closing Balance	3	14	6					
		24	0	0			24	0	0
						By Opening Balance	3	14	6
	To Closing Balance	3	15	0	Y	„ Govt. (Obsn.)			6
		3	15	0			3	15	0
						By Opening Balance	3	15	0

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DEFENSIVE POSITIONS ON OPEN GROUND.

Solutions by MAJOR J. C. MATHESON, R.E., *of Problems in October*, 1906 *number; with Note by* MAJOR A. T. MOORE, R.E.

THE following are considered to be the best of the solutions received of the two Problems published in this *Journal* of October last.

The map was a reduction of the 6″ Ordnance Survey, with details omitted, and with place-names altered so as to put all competitors on the same footing. The ground represented is actually that immediately east of Lewes, Kingston on the map being Lewes and North Hill the site of the Lewes Golf Links. An enthusiastic golfer in that neighbourhood might usefully combine a little instruction with his pleasure by studying these Problems on the spot.

It may be well to recapitulate the topographical conditions governing the Problems.

Below the 50′ contour the country is practically dead level, consisting of marshy fields intersected by numerous small ditches. Between the 50′ and 200′ contours are cultivated fields, with low hedges about 250 yds. apart. Above the 200′ contour is open grass land, with chalk soil.

South-east of the Position is a ridge running due east and west, its summits varying from 600′ to 800′ in height. The western-most height of this ridge is Asham Hill, 625′ high, 3,500 yds. south-east of the old "Camp" on South Hill. Asham Hill is thus within distant to long field artillery range of the whole of the position, except the northern spur of North Hill, and within effective field artillery range of the southern end. The extreme range of the 5″ (Field) Howitzer is practically the same as that of the 18-pr. Q.F. Field Gun.

Except for this ridge the country north and east of the Position is practically dead level for several miles.

In Problem A the R. Arun is unfordable everywhere; the R. Stone is unfordable up to a point 1 mile due east of Wakelands. In Problem B these rivers are non-existent.

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PROBLEM A.

A RED Force has been defeated by a BLUE Force at AYLESFORD (east of the map) and is retiring to GRINSTEAD (west of the map).

You are in command of the RED Rear Guard, consisting of

2 Companies M.I.,
1 Battery R.F.A.,
2 Battalions Infantry,

with orders to cover the passage of the Baggage and Supply Columns of the Main Body over the River ARUN and through the steep narrow streets of KINGSTON.

On arriving at 12 noon on 4th July at the NORTH HILL—SOUTH HILL position, you receive information that (a) *the Baggage and Supply Columns will not be clear of KINGSTON until 6 p.m. the same day, and* (b) *the Enemy's Advanced Guard (strength unknown) reached LAUGHTON (12 miles east of WAKELANDS) at 12 noon the same day.*

As Commander of the RED Rear Guard

(a) *Explain how you would dispose your troops,*
and (b) *Describe the entrenchments you would make.*

SOLUTION

by MAJOR J. C. MATHESON, R.E.

The governing conditions seem to be as follows :—

(1). The enemy cannot make his presence felt until about 3.30 p.m. and you cannot retire until say 6.30 p.m. So that, roughly, you have 3 hours to prepare the position and 3 hours to hold it before retirement.

(2). In the time available you cannot both execute and conceal efficient fire-trenches, your head cover will necessarily be very weak, and over-head cover will be non-existent.

(3). The strength of the enemy is unknown, but a superiority of artillery positions seems indicated. It is not at all certain that his artillery will go at once to ASHAM HILL; if it does, guns on SOUTH HILL, otherwise well placed, will have a bad time. Still, time is of the utmost importance; I should therefore put a section of the battery there, and thus try to lead the enemy to think that you are occupying it. To assist this idea, the soil of the old "Camp" might be turned up a little, and a dummy trench dug near the guns, should time permit. The two guns would be of great use at first; and, if outclassed, could easily retire.

(4). The RIVER ARUN is unfordable everywhere. So an attempted turning of your right flank is practically impossible in the

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time, unless the bridges over the RIVER STONE are captured. There are at least five of these. It seems very doubtful if they could be destroyed in the time available, as explosives are not carried; so they must be well watched.

(*a*). *Disposition of Troops.*

Under the above conditions I should place the troops as follows:—

Artillery.—One section on SOUTH HILL about 200 yards north of the old "Camp." If obliged to fall back, they must retire by ROMAN BOTTOM to ASHTON COL, where they are completely sheltered from ASHAM HILL.

Two sections on the northern slopes of NORTH HILL, where they are 6,500 yards from ASHAM HILL.

Mounted Infantry.—They must leave their tools for some of the infantry to prepare trenches on the north and east sides of ASHTON PARK; retirement to be by ASHTON COL. Meanwhile they would keep in touch with the enemy, and would only occupy their trenches when driven in.

Infantry.—No. 1 Battalion: 4 companies about contour 180 on the north-east slopes of NORTH HILL, to watch the road through MIDDLEHAM, retirement to be by left flank. 3 companies between the first four and the commencement of the WINDMILL HILL spur, retirement to be by ASHTON COL. 1 company on the extreme northern end of NORTH HILL, to watch the left flank. 2 machine guns in BRIGDEN'S SHAW, to watch the three bridges in front of them.

No. 2 Battalion: 4 companies in STONEHAM PARK and STONEHAM, retirement to be by ASHTON COL. These companies must watch the two bridges in front of them with two machine guns. 2 companies in the horns of COURT WOOD about the 200′ contour. 2 companies in reserve in ROMAN BOTTOM, as the right flank may want strengthening.

The Dispositions are shown approximately on the Map.

(*b*). *Entrenchments.*

To carry out the entrenchments, it has been assumed, since no tools are mentioned, that those carried by the troops are available, of which the principal are:—

	Picks.	Shovels.		
Battery R.F.A.	18	36	and some cutting tools	and crowbars.
2 Battalions	296	444		
2 Cos. M.I.	27	55		

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The tools of the 2 battalions must be pooled for the time. If any tools from the headquarter wagon of the brigade are present, these will be used by the 2 companies in reserve in ROMAN BOTTOM, to make the dummy trench on SOUTH HILL and turn the earth on the old "Camp" parapet.

The guns must entrench themselves as well as they can with the tools available in the battery. If there is time, alternative emplacements should be prepared; the 2 guns on SOUTH HILL must certainly have other emplacements ready at ASHTON COL. Considering the ground the entrenchments for the guns should be gunpits; these are more easily concealed than epaulments. The parapets must be carefully sodded.

As regards the infantry, the only cover that can be got in the time will approximate to the 3′ by 3′ trench with 1′ 6″ command, and this command should be ample on this site. To excavate his portion of this trench each man must have a shovel and the occasional use of a pick, and he would require the whole of the three hours available to do 6 feet run.

The amount of entrenching possible is very limited, and only 100 yards of front have been taken up for one company. As each man is to do 6 feet run of trench, for a company trench 50 men with 50 shovels and 25 picks are necessary. The trenches should be traversed every 10 yards; this can be done in the time without any extra labour. It is hardly likely that any time will be available for the construction of head-cover or for the concealment of the parapets, but these two points must be borne in mind.

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PROBLEM B.

NORTH HILL--SOUTH HILL forms the N.E. Section of a continuous line of defence, which has been taken up to protect at all costs a large Supply Depôt at rail-head.

You are in command of this Section and a force consisting of

1 Battery R.F.A.,
2 5″ Howitzers.
2 Sections, Field Company R.E.,
1 Brigade Infantry,

and have a week to make your preparations. Civilian labour and tools are procurable.

As Commander of the Section

(a) *Explain how you would dispose your troops,*
(b) *Describe the entrenchments you would make,*
and (c) *Give a rough working table for labour and materials.*

Note.—As the map is limited the effect of the adjoining Sections of defence must be ignored. It will simplify matters to assume that the strength of the enemy is equal in artillery and double in infantry, and that the Rivers Arun and Stone are non-existent; but Asham Hill remains as a thorn in the side of the defenders.

SOLUTION

by MAJOR J. C. MATHESON, R.E.

The governing conditions appear to be as follows :--

(1). There is sufficient time and labour to make good entrenchments, which can be provided with head and over-head cover, and the parapets can be assimilated to the background and surroundings.

(2). The action will be a deliberate one and the defending troops will want relief and reinforcement. This can be effected much more easily in the case of trenches near the crest than in the case of those far down the forward slope. The cover afforded and the field of fire will also be better from the higher position.

(3). In deliberate actions it is a mistake to expend time and labour on several positions. It is much better (unless there is an unlimited amount of labour available, and very strong garrisons) to make certain that one line, the one which you mean to hold, is strong. Therefore, in this position there are no advanced posts and ASHTON and STONEHAM PARKS are not occupied.

(4). ASHAM HILL practically commands the whole defensive position within distant range, except the extreme north-west end of NORTH HILL. The trenches should be constructed with over-head cover, which permits the garrison to man them and use their

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rifles even under artillery fire. The howitzer fire must be risked; it will be a long time before it will have any appreciable effect on a line of well-traversed trenches.

(*a*). *Disposition of Troops.*

For their actual fighting positions I should place the troops as follows:—

Artillery.—2 howitzers in ROMAN BOTTOM. 4 field guns on the north end of NORTH HILL, and 2 on ASHTON COL.

Infantry.—No. 1 Battalion:—2 cos. in trench '*a*.' 4 cos. in trench '*b*.' 2 cos. in reserve in redoubt 'Z'; this is 6,700 yards from ASHAM HILL, the only commanding hostile artillery position, and so is practically out of distant range; it will be only just visible, and can be made very inconspicuous.

No. 2 Battalion:—2 cos. in trench '*c*.' 2 cos. in trench '*d*.' 2 cos. in trench '*e*.' 2 cos. in reserve in SAXON BOTTOM.

No. 3 Battalion:—2 cos. in reserve in redoubt 'X.' 2 cos. in reserve in redoubt 'W.' 4 cos. in COURT WOOD.

No. 4 Battalion:—4 cos. in old 'Camp' trenches. 2 cos. in trench '*f*.' 2 cos. in reserve in ROMAN BOTTOM.

2 *Sections Field Company R.E.* in reserve in KINGSTON BOTTOM.

Ordinarily, when an attack was not in progress, the troops in the front trenches would naturally be very much reduced.

The Map shows the approximate positions of the trenches and redoubts.

(*b*). *Entrenchments.*

Civilian labour and tools are available, but one can hardly assume these to be unlimited. I have requisitioned 1,700 men per diem in 2 reliefs of 6 hours each, together with as many carts as possible. These latter are to remove the surplus earth from the cover trenches, which earth should be heaped at some distance from the real trenches to form dummy ones; dummies may do no good, but, if at some distance, will do no harm. The cover trenches give alternative cover to the fire-trenches.

All the fire-trenches have over-head cover to allow men to use their rifles under fire. Each man is between traverses (*i.e.* in a recess in the parapet). This should reduce loss to a minimum.

The old "Camp" end of SOUTH HILL is important and very exposed. Here fairly long trenches are proposed in order to allow reserves to remain at the front if necessary.

Three redoubts have been made to support the trenches, and should prove valuable *points d'appui* in the event of the fall of the line of trenches being threatened. Redoubts 'W' and 'X' are unseen from any part of the enemy's line, even from ASHAM HILL. Redoubt 'Z' is just visible from ASHAM HILL only, and is 6,700 yards away

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from it, and so is practically out of distant range of field guns and field howitzers.

On these open downs trenches completely sunk should give ample field of fire. (N.B.—In Problem A these low trenches could not be made owing to lack of time).

(*c*). *Labour and Materials.*

Without a knowledge of the ground itself, it has been impossible to put the execution of the works in any order of precedence, one can only give the men, tools, and total time required to carry them out; these are shown in the attached rough Table.

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ROUGH WORKING TABLE.

Place.	Work.	No. of Men at One Time (6-hour relief).	Time Required to Execute.	Tools and Materials.						
				Picks.	Shovels.	3" Poles.	Roofing Material.	Saws.	Wire or Rope.	Sundries.
						ft. run	sq. ft.			
NORTH HILL	Trench 'a,' 200 yds.	160	18 hours	120	120	—	720	—	—	
	Cover trench 'a,' 50 yds.	40	18 ,,	30	30	830	1350	3	wire or rope	One or two carts to remove surplus earth.
	Commn. trench to 'a' and 'Z,' 200 yds.	100	6 ,,	100	100	—	—	—	—	
	Trench 'b,' 400 yds.	320	18 ,,	240	240	—	1440	—	—	
	Cover trench 'b,' 100 yds	75	18 ,,	60	60	1660	2700	6	ditto	ditto.
	Commn. trench to 'b,' 550 yds.	275	6 ,,	275	275	—	—	—	—	
	Trench 'c,' 250 yds.	200	18 ,,	150	150	—	900	—	—	
	Cover trench 'c,' 75 yds.	55	18 ,,	45	45	1245	2030	5	ditto	ditto.
	Commn. trench to 'c,' 750 yds.	375	6 ,,	375	375	—	—	—	—	
	Trench 'd,' 250 yds.	200	18 ,,	150	150	—	900	—	—	
	Cover trench 'd,' 75 yds.	55	18 ,,	45	45	1245	2030	5	ditto	ditto.
	Commn. trench to 'd,' 450 yds.	225	6 ,,	225	225	—	—	—	—	
ASHTON COL.	Trench 'e,' 250 yds.	200	18 ,,	150	150	—	900	—	—	
	Cover trench 'e,' 75 yds.	55	18 ,,	45	45	1245	2030	5	ditto	
	Commn. trench 'e,' 300 yds.	150	6 ,,	150	150	—	—	—	—	
COURT WOOD	Trenches, 300 yds.	240	18 ,,	180	180	—	1080	—	—	
	Commn. trench from 'X,' 200 yds.	100	6 ,,	100	100	—	—	—	—	
SOUTH HILL	Old "Camp" trenches, 550 yds.	440	18 ,,	330	330	—	2000	—	—	
	Commn. trenches, old "Camp," 350 yds.	175	6 ,,	175	175	—	—	—	—	
	Trench 'f,' 250 yds.	200	18 ,,	150	150	—	900	—	—	
	Cover trench 'f,' 75 yds.	55	18 ,,	45	45	1245	2030	5	ditto	ditto.
	Commn. trench to 'f,' 150 yds.	75	6 ,,	75	75	—	—	—	—	
NORTH HILL	Redoubt 'Z'	170	12 ,,	140	140	some revetting material wanted, labour is allowed for.				
SOUTH HILL	Redoubts 'X' and 'W'	360	12 ,,	300	300					
Whole position	Gun entrenchments	Made by R.A. : guns on NORTH HILL want special protection on right flank.								
	Clearance of hedges, etc.	As may be necessary.								
	Obstacles	Impossible to detail, depends on wire, etc., available.								
	Collecting and carting roofing material	400	12 hours	—	—	—	—	—	—	A number of carts.

Allowing for making clearances and obstacles, the above works out at about 1,700 men per day in 2 reliefs (850 each), for 7 days. Entrenching tools required are about 600 picks and 600 shovels. For roofing materials, brushwood, corrugated iron, etc., etc., can be used.

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REMARKS.

The above cases of positions on open ground are good examples for illustrating the different factors which must be taken into account in all fortification, and especially in field works.

It is impossible here to consider all these factors; but there is one beyond all others that the two problems bring into relief, and that is the extreme importance of *time* in preparing a position for defence. With the word time is also included labour, by which time is turned to good account.

Perhaps the most difficult problem in the art of fortification is the preparation of a position in a few hours. Let anyone try to imagine the conditions. A force arrives on a position in an unknown country, and an officer receives orders to prepare the position for defence against an attack expected in a few hours. Of course some data are known,—the strength of the force for fighting and labour, and possibly the approximate numbers of the enemy. But the chief point is that the ground is new, the nature of the soil may be unknown (a very important matter), and the longer the time taken up in studying the position the shorter the time available for preparation. And there are many points that have to be weighed,—the nature of the action to be fought, the necessity for good field of fire, cover, invisibility, power of reinforcement, power of retirement, etc. Many of these requirements must be omitted or compromised through lack of time. Then is the moment for the genius with an "eye for country"; he will be worth several companies.

What an Utopian training would be the chance for an R.E. or any officer to have the actual preparation of such a position under these conditions, with due criticism and discussion afterwards. But it would be Utopia and not England or any other known country.

Turn to the Problem B and see what a change the factor of time has wrought. Is the field of fire obstructed? Time will surely improve it. Trenches can now be made of any desired type, superfluous earth can be removed, and the "slim" art of deception is possible. In fact, in almost every way time will allow the defects of nature, as regards the particular position, to be made good.

To come back to Problem A, the more difficult one, the design of the trench is a very secondary matter compared to its *site*, which is the crucial point. Everyone now knows how a trench should be made; for the siting no definite rules can be laid down. But it is evident that, since time is so limited and a certain amount of excavation is essential (namely the irreducible minimum to give effective cover), there will be very little time to spare for concealing the parapet, for making head-cover, or for digging communications up to the trenches; and so the site must be looked to to provide as far as possible for the requirements in these respects.

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In this particular case it is evidently necessary to get below the chalk line, unless the trenches are to present an excellent target to the enemy. Retirement from these forward positions will be attended with danger; but this must be risked, and those lines of retreat chosen which are most concealed by nature. One small point here is in favour of the defenders,—owing to the orientation of the position, the forward slope should be in shadow when the retirement is to take place.

NOTE BY MAJOR A. T. MOORE, R.E.

It must always be a matter of difficulty to evolve a satisfactory solution of a tactical problem by means only of a map. In the cases here under discussion the difficulty is by no means diminished by an investigation of the actual ground; and to arrive at the best solutions would entail a detailed yard-by-yard examination of the position and a considerable expenditure of time (not permissible under the conditions of Problem A).

Having visited the ground and discussed the features with other officers who have been there, I may be justified in making some remarks on the considerations which led me to think that Problem A was of peculiar interest.

(1). *The Topography of the Defensive Position.*—Though Asham Hill is of serious import in Problem B, it is of less significance in Problem A, since the duration of the operations is limited and it will be some little time before the enemy learns the value of this hill and gets his artillery there; his guns will have to come into action in daylight against guns already in position; and it is only the extreme south end of the position that is within effective range of field artillery on this hill.

Roughly speaking, the whole of the position above the 400′ contour, except the north side of North Hill and the reverse slope of South Hill, is within full view of Asham Hill; and it must be remembered that this hill is not an isolated one, but portion of a ridge which rises some 200′ higher at points further to the east. On the other hand, practically the whole area of the three Bottoms is out of view by the Enemy, and the whole of the northern flank of North Hill and the greater part of its north-eastern side are also defiladed. The probability is that from Asham Hill the existence of the Bottoms would not be discovered, as from this distance North and South Hills, being open grass land, would appear one plateau. (It is assumed that the Enemy would have maps of the country, but small scale maps on which the configuration of the ground would not be shown in detail).

The only crossings over the R. Arun (concerned in the problem) are the railway bridge south of Kingston and the road bridge in this town. The former is probably unsuitable for vehicles and horses, it is

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commanded by the whole position, and there is a considerable extent of open dyke-covered ground on the right bank of the river here. The road bridge is defiladed by the ground, as well as by houses, from the whole of South Hill ; this crossing is therefore the most important for both sides.

North Hill forms a most efficient natural bridge-head for the road bridge ; this hill could be held after South Hill had been captured, but it is doubtful whether the converse would be true. Hence North Hill is the key of the position.

As the country north and east of the position is practically dead level and open for several miles, the line of the Enemy's advance would, in July weather, be discovered at an early period ; so there would be no question of a surprise.

(2). *The Probable Action of the Enemy.*—The Enemy would soon discover, if he did not know it already, that Red's baggage and supply columns were in difficulties. The possibility of capturing them would induce him to push on ; and his attack would probably be developed by 3.30 p.m.

He would endeavour to prevent all, or at any rate a portion of, the columns from crossing the R. Arun. Hence, for reasons deduced from the above topographical considerations, his principal physical objective would be North Hill.

He would be headed off from an attack on South Hill from a southerly direction by the unfordable R. Stone with its few crossings all under close fire from the position, and would eventually arrive in the neighbourhood of Wakelands. Here there would be two alternatives for him :—(1) To make an attack from the north-east over open ground direct on his main objective, viz., North Hill ; or (2) to take advantage of the cover afforded by Ashton and Stoneham Parks and Court Wood in order to first occupy South Hill, and thence proceed to attack North Hill. Though the latter course might occupy more time, which is of importance to him, he would probably adopt this alternative. In any case his attack would probably be supported by artillery fire from Asham Hill.

The fight would then resolve itself into two distinct phases from Red's point of view, namely a rear-guard action on South Hill and a protracted resistance on North Hill.

(3). *The Occupation of the Defensive Position.*—Allowing only ½ an hour for examining the position, Red commander would have a maximum of 3 hours to make his preparations ; and he must hold North Hill at any rate for a minimum of 2½ hours.

In occupying a rear-guard position, one axiom is to ensure a good line of retreat ; in this case there are the two bridges immediately in rear.

Since the pursuing force would endeavour to work round the flanks, another axiom is to have strong flanks ; in this case, the flanks are

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naturally strong, whether we consider the whole position or only North Hill.

A third axiom is to ignore the immediate foreground of the main infantry firing line, for the rear-guard would retreat before the Enemy arrived at anything like close quarters. But in this particular case, since the baggage and supply columns may be delayed beyond 6 p.m., it may be necessary to make a stubborn resistance. Owing to the peculiar convex formation of the terrain, any line along the top of the hill has the disadvantage of so great a depth of dead ground in front that the attacking infantry would be under cover long before they arrived within decisive rifle range; also, the top of the hill is too narrow to provide an effective field of fire for a line placed on the rear crest; lastly, since the soil above the 200′ contour is chalk, any trenches made above that level would give the position away at once, as there would be no time to disguise and conceal them. Hence, at any rate on the north-eastern side of North Hill, the main infantry firing line must be well down the forward slope.

As regards the Disposition of the Troops, the following are the conclusions arrived at with some knowledge of the locality :—

Red's force is too small for any portion to be sent up to Asham Hill in order to delay the occupation of this commanding position by the Enemy; and any troops sent there for such purpose would be liable to have their retreat cut off.

The force is also too small to permit of Windmill Hill being occupied effectively, and without danger, as part of the main line of defence; but some portion of the mounted infantry might have occasion to hold its northern face temporarily.

The mounted infantry, after getting early information of the main line of the Enemy's advance and delaying him as long as possible, would retire by the flanks, and would eventually cover the retirement of the infantry by occupying the trenches vacated by them; they might have to occupy first the position on South Hill and then that on North Hill, or the latter only.

The best position for the artillery is on the northern spur of North Hill, which is beyond distant field artillery range from Asham Hill and from which there is an excellent field of fire to the north and north-east. It would be advisable to place 1 section "in observation" just behind the crest on Ashton Col, whence they could operate against an attack on South Hill from the east or bring a flanking fire on an attack on North Hill, eventually retiring on to the latter.

The main strength of the infantry should be on North Hill. No. 1 Battalion could be entrenched at suitable points about the 200′ contour on the north and north-east slopes; there would be little possibility of reinforcement, and the only route for retirement would be a somewhat hazardous one by the left flank. If trenches on the upper edges of

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the quarries on the north slope could be assimilated with these edges, the companies on this flank might be disposed just above the quarries instead of on the 200′ contour.

2 companies of No. 2 Battalion might be placed as a reserve in the hollow on the west side of North Hill; and should construct entrenchments along the south-west spur of this hill, from whence they could cover the retirement of the troops on South Hill and also oppose an attack from that direction. If the forward slope permitted of these trenches being on the crest, the surplus soil could be removed out of sight down the reverse slope.

The remaining 6 companies of the second battalion would be disposed behind the crest of South Hill, 4 between Ashton Col and the southern extremity of Court Wood, and 2 on and to the north of the old "Camp." These companies would not entrench, and would only come into action along South Hill in order to repel an attack on that part of the position; they would be available for reinforcing or supporting the troops on North Hill.

So far as time permitted, dummy trenches would be constructed on conspicuous sites on the unoccupied portions of the various crests and slopes, in order to mislead the enemy and draw his fire.

The infantry could retire partly by one bridge and partly by the other or by the road bridge only, the mounted troops and guns by the road bridge. The artillery and mounted infantry would retire last, and it might be necessary to sacrifice them in order to gain time for an orderly retreat of the baggage and supply columns and the infantry.

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OUR REQUIREMENTS IN RIFLE RANGES.

By Capt. A. B. Carey, R.E.

The provision of suitable and sufficient rifle range accommodation for the efficient musketry training of our forces is a problem of great difficulty. This question is one far more difficult of solution in Great Britain itself than in Colonial or Foreign countries which are less densely populated and where large open areas of land are comparatively easily obtained. It is, moreover, a question of which the difficulties are accentuated by two factors :—

(*a*). The increasing ranging power of modern weapons.
(*b*). The increased amount of musketry training which is recognised as necessary for both the Regular Army and the Auxiliary Forces, whether those auxiliary forces consist of volunteers and militia or are obtained under some form of universal training.

The subject should be considered from its origin, as it is evident that under present conditions the practices laid down in the Musketry Regulations necessarily conform to the type of rifle range available on which to execute them ; whereas, when the construction of a new range is about to be undertaken, the chief consideration is usually how it can be made most suitable for the practices laid down in the Musketry Regulations. Unless, therefore, a periodical consideration of the question is taken up *ab ovo*, it will follow that, in spite of strenuous endeavours on the part of the officials responsible for this portion of the training of our army, musketry instruction will fall largely into a groove bounded on both sides by the narrow limits of existing range accommodation. As an instance of this may be quoted the snap-shooting practices introduced into the Musketry Regulations after the Boer War, and the fact that on a large number of ranges these practices have to be deleted as the danger areas have been found insufficient.

It is therefore necessary to consider first—What is the object of musketry instruction, both as regards the individual soldier and his fire commander ? and afterwards—What means have we available for providing this instruction, and what form should the provision of new accommodation take in order to meet modern requirements and developments in the near future ?

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OBJECTS OF MUSKETRY INSTRUCTION.

The objects of musketry instruction may be divided into three sub-heads :—

(*a*). To enable the soldier to use his rifle to the best advantage on service under conditions where it is possible for the individual to select his own target and to have a reasonable chance of hitting it.

(*b*). To enable the fire leader to direct the fire of his party to the best advantage under conditions which prohibit the use of purely individual fire as above.

(*c*). To inculcate such fire discipline into the individual soldier as to ensure that he will obey the commands of his fire leader even under the stress of modern battle conditions.

(*a*). Now the soldier may be called upon to use his rifle under widely varying conditions. At one time he may be firing under the command of his fire leader, who will have pointed out the object to be aimed at, and will give the range to be used and will adjust it as he may consider necessary from his observation of the results of the fire. Or he may be called upon to fire, upon his own initiative and with no time for reflection, at short range, at single figures, possibly showing only their heads and shoulders, and these indistinctly and for short intervals of time as they move from cover to cover or appear for an instant to fire.

Between these two extreme types of condition lie many intermediate stages. But it is the latter set of conditions that calls for the highest skill and therefore the highest degree of instruction for the individual soldier, in that he must be able firstly to see the enemy, possibly a few indistinct objects against a dull background, secondly to select his target, estimate the range, and align and fire his rifle with an almost automatic rapidity. This high degree of skill is more likely to be called for on small expeditions than during a war with a great power where larger numbers are in question and battle conditions with controlled fire would more frequently prevail. But even under these latter circumstances individual skill would find many opportunities both in the skirmishing preceding the battle and even during the battle itself; and although the fight may be won eventually by superior direction of the fire of masses of men, yet it would appear equally certain that a high degree of skill on the part of the individual firers will count largely in the conditions leading up to the battle, and will, other things being equal, give increased power of reconnaissance and greater facility for seizing and holding important points at a distance from the main body.

It is evident therefore that our Regular Forces, which are frequently called upon to take part in small expeditions, should be trained to as

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high a degree of skill as possible in firing, at decisive ranges, at figure targets appearing at unknown distances and in unexpected directions so as to simulate as far as possible actual service conditions; whereas our Auxiliary Forces should have at least some instruction in firing of this description.

(*b*). For the fire leader to be able to direct the fire of his party satisfactorily in war, it is necessary that he shall have had some practice in time of peace in observation and direction of fire at targets made to resemble service conditions as far as possible and appearing at unknown ranges and unexpected times and directions.

(*c*). As regards this point, a reasonable amount of training under sub-heads (*a*) and (*b*), carrying with it necessarily the increased confidence of the individual in himself and his weapon, without which fire discipline is scarcely attainable, should provide all that is necessary. It should also be noted that, whereas it will not be practicable (and is indeed scarcely necessary) to train the Auxiliary Forces to the same high degree of individual skill in the use of the rifle as is necessary for the Regulars, yet their training for what may be described as battle firing should not fall far short of the standard laid down for the Regulars; and the selection and training of their fire leaders should be performed with the greatest care, in order that the fire discipline and control should attain the highest practicable degree of efficiency.

To analyse then the requirements of musketry instruction for the individual soldier, these consist of:—

(1). *Mechanical Motions.*—Handling of the rifle quickly and correctly, and aligning sights, including knowledge of the peculiarities of his own rifle, pressing trigger, quick loading.

(2). *Intelligent Motions.*—Spotting enemy, selecting target, judging distance up to short ranges (say 500 yards) at the same time as he is choosing his own firing position and commencing the mechanical motions of firing.

The fire leader, in addition to the attributes enumerated above, should have some knowledge of the effect of wind and other climatic conditions, should be trained to use glasses to assist in spotting and selecting his target, and should also be trained to judge distance up to medium ranges or be supplied with a range-finder * which is portable and convenient to use and accurate up to 1,500 yards.

* Of course if a range-finder can be obtained, which will combine accuracy at long ranges with convenience and portability for short range work, this would be most desirable, but convenience and portability are not such essential conditions for use at the longer ranges. Larger bodies of men are necessarily employed under better control, rapidity of range-finding and invisibility of the range-taker are not of such essential importance, and it might perhaps be sound policy, while supplying numerous small range-finders to fire leaders of low rank, to supply also range-finders of a longer base, and consequently of greater accuracy at long ranges, for the use of fire-leaders of higher rank.

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DESCRIPTION AND EXTENT OF TRAINING OBTAINABLE UNDER PRESENT CONDITIONS.

Preliminary instruction in handling rifle, setting sights, aiming, and trigger pressing is given on the drill ground, and possibly on Morris Tube ranges; also judging distance, and some practices for improving the eyesight, but each subject by itself.

For further and practical instruction there are three types of range available :—

(*a*). The Classification Range.
(*b*). 30 Yards Range.
(*c*). Field Practice Range.

(*a*). *The Classification Range* is the best known and exists in the largest numbers; for this reason it is being dealt with before the 30 Yards and Field Practice Ranges. It allows for the completion of the instruction of the individual in the mechanical motions; that is, the soldier is enabled to detect errors and correct himself in aiming, trigger pulling, flinching from recoil, etc.; and is on some ranges able to practice rapid fire and snap shooting at simple moving or vanishing targets at known distances, though this cannot be carried out on all classification ranges. He is also able to learn the peculiarities of his own rifle and get some knowledge of weather conditions.

The disadvantages of this type of range are that for the individual soldier it is impossible to carry out practices resembling service conditions when range, direction, and time are unknown. For the fire leader the ordinary classification range is practically useless; he may be able to obtain some knowledge of weather conditions, but this type of range affords no instruction in fire observation, direction, control, or discipline.

The chief feature of a classification range is that it provides an opportunity for practice at medium ranges in the effects of wind and light. Setting aside the fact that the value of these lessons would be largely discounted on service in another country with a different climate, there remains the fact that accurate individual shooting at these ranges is entirely dependent upon accurate marking. On service there will be no marking, and accuracy can only be looked for by good range-finding followed by skilled observation of controlled fire; corrections for individual shots for slight alterations in the strength of the wind or the quality of the light will be impossible. It therefore follows that, while the fire commander should have some general knowledge of the effects of wind and weather conditions, the degree of skill in this subject required to win prizes at Bisley is quite unnecessary and his time would be far better employed in studying observation and control of fire.

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(*b*). *30 Yards Ranges.*—These ranges allow the individual to perfect himself in all the mechanical portion of firing, including rapid fire, to obtain by means of double targets some knowledge of the peculiarities of his rifle, and to perfect himself in the use of the dial sights. Like the classification range, however, they provide no training in the subjects which require the use of the firer's intelligence, nor do they provide any training for the fire leader.

(*c*). *Field Practice Ranges* should theoretically supply all the deficiencies of the two types of range described above. In reality, however, they are at present too small and not suitably laid out, with the result that, although some opportunity is given to fire leaders to observe the effects of fire at moving and vanishing targets and some training in fire discipline and control is afforded, yet this instruction is insufficient even for the fire leaders; and little or no opportunity is afforded of practising the individual firer in those exercises which oblige him to use simultaneously both his intelligence and his mechanical skill and are the only means by which a reasonable degree of skill in shooting under service conditions can be attained.

ADVANTAGES AND DISADVANTAGES OF PRACTICE AMMUNITION.

There are three possible types of ammunition for practice purposes, viz. :—

(*a*). Miniature Ammunition.
(*b*). Reduced Charges.
(*c*). Break-up Bullet.

(*a*). *Miniature Ammunition* is cheap. It has little penetration, and consequently the stop butt and other construction is not costly. It is, however, useful only as a preliminary step between aiming drill and firing service ammunition.

(*b*). The same remarks apply to *Reduced Charges.* It must never be forgotten that, after aiming drill, the first and chief requirement of musketry instruction is to teach the firer to become accustomed to the shock of recoil and to load and fire equally correctly whether he has a service charge or an empty chamber. Teaching rifle firing must not be confused with big gun firing, which is absolutely dissimilar for the reason that in the first case the firer holds the weapon and receives the shock of discharge, whereas in the latter case these functions are performed mechanically.

Firing reduced charges practically amounts to doing a better class aiming drill. For rifle shooting it does not give the main desideratum, viz. :—practice in becoming accustomed to noise and shock of recoil.

Further it must be remembered that any ammunition, either miniature or reduced charges, which will shoot accurately at 200 yards,

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will require a danger area of many hundred yards. For instance, the Bisley pattern Morris Tube ammunition has a maximum range of about 1,300 yards and a ricochet range of about 500 yards. Kynoch's B reduced charge is rather more dangerous as regards ricochets. Moreover, the use of these forms of ammunition in field practices up to 500 or 600 yards is greatly to be deprecated, because, even if they shot straight enough, owing to greater elevation being required the firer would become habituated to holding his rifle at too great an angle of elevation, and consequently on service he would be liable to repeat this error, especially under battle conditions when accurate sighting is scarcely probable. Another drawback to the use of these types of ammunition is that, owing to invisibility of strike of bullet, the fire leaders would get little or no instruction in observation and control of fire, a point of considerable importance.

It may be urged that possibly a special practice ammunition might be devised which, being more powerful than existing types of reduced charge ammunition, would give with a very light bullet a high muzzle velocity and considerable recoil and noise with the advantage of a flat trajectory at short ranges; but, owing to the unfavourable sectional density, the bullet would rapidly lose velocity and would have considerably less ranging power than the service bullet. This may or may not be possible; the difficulty would be to ensure accuracy with such a light bullet. Even if this were obtainable, however, it is very doubtful whether a sufficient saving in depth of danger area could be effected to counterbalance the expense of making a special ammunition and the disadvantages of it from a training and ordnance point of view. For instance, the main disadvantage from a musketry point of view of such a type of ammunition would be that the errors in sighting of each individual rifle would differ when used with service ammunition to what they were when this special practice ammunition was used; *e.g.* a man may learn that his rifle with practice ammunition at 500 yards throws 2 feet left and is 50 yards undersighted, whereas at the same distance with service ammunition it throws perhaps 1 foot right and is somewhat oversighted. The confusion arising in a soldier's mind from having two sets of corrections to remember would be a grave disadvantage.

(*c*). *Break-up Bullet.*—As regards the use of a bullet which would break up on impact, this would, if practicable, be very desirable, and would tend to reduce the range of ricochets by at least one-half; but I am not hopeful of this solution of the question being attainable. The shocks received by the bullet while in and on leaving the barrel are very much more severe than the shock received on lightly grazing a smooth and possibly soft soil. Consequently it must not be expected that a bullet which will stand the shocks of propulsion in the barrel and discharge from the muzzle of the rifle, although it is

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to some extent supported by the sides of the barrel during these, will be so fragile as to break up on grazing a soft and yielding substance. Of course, if it could be guaranteed that the bullet would strike the earth nose first, the case would be different, and comparatively certain results might be looked for; but this is not attainable, and it must be accepted that large numbers of ricochets would have grazed the earth on their undersides only. I am therefore forced to the unwelcome conclusion that a segmental or fragile bullet will not form a solution to this difficulty.

SUITABLE TYPES OF RIFLE RANGES.

Long *Protected Ranges* have been abandoned. But in view of the fact that some misunderstanding possibly exists as to the value and degree of safety of these ranges, it seems desirable to append the results of considerable experiment at Hythe and of experience gathered from ranges of this type both on the Continent and in Great Britain.

1. A well-designed and economically constructed protected range of 200 yards costs about £200 per target.

2. Absolute safety is not attainable unless the range is practically converted into a tunnel, when its training value decreases and its cost increases.

3. As regards training value a 30 yards range is the superior of the 200 yards protected range, in that it permits of rapid fire, use of long range sights, etc., and especially of quicker instruction.

4. As regards constructional cost the 30 yards range in most unfavourable circumstances would be less than half the cost of the most favourably situated 200 yards range.

5. As regards area of land and accessibility required the 30 yards range again has an immense advantage. The deduction is therefore that, for a densely populated country such as Great Britain, having a comparatively long service army and being dependent for its reserves on auxiliaries who, under any organisation, will spend far less time in their training than obtains in the reserves of continental armies, the three main points to consider are safety, rapidity of instruction, and accessibility. On all these points the 30 yards range is far in advance of the 200 yards protected range.

For instruction in the mechanical portion of musketry the 30 yards range, or the classification range if sufficiently close at hand, are suitable. For the instruction in weather conditions of fire leaders or men likely to become fire leaders the classification range is suitable, though it is a very expensive item to provide for this one item in musketry instruction and is often inconveniently situated. For the further instruction of the individual in firing under what may be called snap-shooting conditions, and for the instruction of the fire

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leader in his duties, the 30 yards and classification range are useless and the present type of field practice range is unsuited.

It will be seen, therefore, that both the types of existing ranges and also their numbers and accessibility are not up to requirements. The *Classification Range*, which type alone exists in any numbers, is quite inadequate for musketry training to meet modern conditions. It provides limited opportunities for our men to become good mechanical shots and to learn the sighting of their rifles; and it does this in a very wasteful and extravagant manner, owing to (*a*) the value of the land and size of danger area required, (*b*) the distance of ranges from the men who use them and consequent expense and loss of time entailed in going to and fro. Moreover, classification ranges, although considerably in excess of the 30 yards and field practice ranges, are still quite inadequate in number for the needs of either our Regular or Auxiliary Forces; and they are particularly unsuited for the elementary training of these latter, owing to the distance from populated localities at which these ranges are usually sited and the limited time which the Auxiliary Forces are able to spare for musketry training.

30 Yards Ranges form a much more economical and convenient means of supplying elementary training in rifle shooting to both the Regular and Auxiliary Forces. But as yet there are very few of these ranges in existence, a defect which it is to be hoped will be gradually remedied since they provide for the cheapest and quickest form of elementary instruction.

That these arguments will be considered as heresies by the Bisley marksman and his following is probable. But the solid fact remains that in war time casualties are not caused by riflemen who slowly and deliberately adjust their elevation and wind between each shot accordingly as a complaisant enemy signals the amount of error to which he still owes his life. No, conditions are very different. Casualties in real war depend much more largely on the probability of one of a number of fairly well-aimed shots reaching its mark; and, after a reasonable degree of mechanical accuracy of firing has been attained, the chief factors in increasing the probability of hitting are:—

1. Well-trained eyesight.
2. Accurate judging distance.
3. Rapid fire.
4. Good fire leading.

The ordinary type of bull's-eye target shooting as carried on at present gives no training whatever under the first two and the fourth sub-heads and very little under the third. I might go further and say that not only does it not help in training the eyesight but it even does harm in accustoming the mind and eye to abnormally easy and slow conditions.

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It is evident therefore that a new type of range is necessary which will provide for training the individual in each of the subjects enumerated above—not each subject separately, but all in combination.

Small Field Practice Ranges.—The first requirement, therefore, is the provision of a sufficient number of separate ranges, on each of which a small party of men can be exercised in offence or defence under the control of its fire leader; the size of the party to be so small that it is practicable for each man to receive individual instruction, for each man to have his own target to shoot at, appearing at unknown times, distances, and directions, but falling when hit.

The targets should be sufficiently far apart for each man to be able to observe the results of his own shots, or for his right or left-hand man to do so for him, and correct his aim accordingly. Practices of this description compel the individual to use both his intelligence and his mechanical skill in combination, and it is ranges of this type that are specially necessary.

The second requirement is that these separate and independent ranges shall be so sited on one area that, when not required for individual instruction, they can be used in combination for the instruction of the fire leaders in direction, observation, and control of fire, and also in covering fire and mutual support. But these practices will only be the secondary purpose of the area, the first necessity being the training of the individual firer, which, besides being of importance in producing good shots, is also of considerable value to the fire leader who will improve himself from watching or firing with his small party of 8 to 12 men.*

For the individual practices, ranges permitting of firing up to 600 yards will suffice, as this distance may be considered well outside the limit at which any individual man can fire with a reasonable prospect of hitting in a few rounds an individual target. For the elementary fire leaders' practices rather longer ranges should be provided. It should be possible also to carry out occasionally firing by large bodies at long ranges, say up to 2,000 yards, and also demonstrative practices at medium and short ranges, such as for instance to show the effect of fire on a small body of cavalry charging.

Although at first sight it would seem that individual practice in firing at moving targets was a very necessary item of instruction,

* This is not intended to imply that practice in direction and control of collective fire is of less importance than individual fire; but that, since ammunition is limited and because the individual practices necessarily occupy a much greater amount of time than collective practices, therefore, in laying out an area, the first consideration must be to so lay it out as to provide the greatest possible amount of accommodation for the individual field practices. This being done it may be taken for granted that sufficient accommodation for collective practices will be easily obtained.

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yet it will be seen on consideration that it is not of great importance and would be wasteful. It would lead to considerable expense in the provision of numerous moving targets; greater risk would be incurred of widely divergent shots; and instruction would be delayed owing to mechanical difficulties. These arguments however are secondary; the main reason for not providing individual practice at moving targets on field practice ranges is that firing such as is practised at Bisley at the running deer does not occur on service. On service the moving target will usually be advancing more or less directly towards, or retiring more or less directly away from, the firer, especially at ranges where purely individual fire is effective. Under these circumstances firing is but little more difficult than if the target is stationary. The more difficult case for the individual is the crossing shot; but here again the Bisley running deer type of shot would nine times out of ten be useless, as the man target would not go at a steady pace along nicely inclined slopes, but would usually appear and disappear with folds or irregularities in the ground, and would vary its pace accordingly, the result being that the firer, if he attempted to follow Bisley practice, would get badly left. The only practical method of dealing with a crossing target on uneven ground is to aim and fire rapidly at the spot which you judge the target will have reached by the time the bullet can get there. A good shot at surprise targets will be able to do this sufficiently well. As regards collective fire at crossing targets on service, these will usually be comparatively large bodies, and steady shooting at the head of the body will do all that is necessary. It is for these reasons that firing at moving targets, such as at a small party of charging cavalry, is classed as a demonstrative practice and is not included in individual instruction.

The provision at each locality of a sufficient number of easily accessible field practice ranges is practically an impossibility; as a range suitable for only one section of 8 or 16 men at a time to carry out individual field practices entails the provision of a danger area of some 800 acres, the cost of which would be very unlikely to be less than £100 an acre if the range was at all conveniently situated. The reason of this large danger area being necessary is that, in order to provide a sufficient variety of direction of fire, an angle of divergence of at least 10 or 11 degrees to either flank must be allowed for; to this must be added the 20 degrees necessary for deviation of ricochets; and it will thus be seen that for field practices of any value to be carried out a danger area far wider than that required for an ordinary classification range is absolutely necessary.

It may therefore be accepted that the provision of single individual field practice ranges in easily accessible situations for each locality is an economic impossibility; and that the only rational means for providing for field practices is by taking up a few large areas of

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ground on which such numbers of individual field practice ranges can be constructed as to reduce the area of ground required per range from 800 to about 200 acres or less, and then to supply these ranges with such a complete outfit of both personnel and target apparatus and appliances as will ensure the possibility of imparting the greatest amount of instruction in the least possible time and will consequently reduce the total number of areas required. A massed number of individual field practice ranges, provided with hutting accommodation so that men can be sent for a course of field practices lasting perhaps a few days for the Auxiliary Forces and a few weeks for Regulars, will have the advantage over the single local individual field practice range that greater variety will be obtainable ; so that, even were the advantage of massing individual field practice ranges not so great from a pecuniary aspect, there would still be this considerable advantage of variety from a training point of view.

Since, however, it would be very wasteful practice to take a man to a field firing practice area to fire ball ammunition until his eyesight and intelligence had been sufficiently developed for him to be able to spot and select his target reasonably quickly, it is most necessary, in order to obtain the full value of these field firing areas, that provision should be made near every station of aiming grounds, not less than 600 yards in length by 200 yards wide, on which practices by small parties (up to say 1 company) can be carried out with or without blank ammunition but otherwise simulating service conditions—in order, (1) to train the individual in rapidly spotting, selecting, judging distance, and aiming at surprise figure targets and in fire discipline, and (2) to give the fire leader elementary instruction in fire direction and control as well as improving his eyesight and rapidity of decision. Such a dummy range as this should be provided with a sufficiency of figure targets and apparatus by means of which the appearance and disappearance of the targets can be regulated at the will of the instructor, so that practices either in attack or defence can be carried out. Cover of various forms should be provided both for the figure targets to appear from and for the men under instruction to be taught to take advantage of ground.

If ever we are engaged in war with a first-class power we shall have to rely on the good average training of large numbers of Auxiliaries rather than the high degree of skill of a small Regular Army. This good average of training is impossible for really large numbers of the Auxiliary Forces under present conditions since rifle range accommodation is not sufficiently accessible. It can only be obtained at a reasonable price by the provision of easily accessible 30 yards ranges and no less easily accessible aiming grounds as described above, the final training being given when possible by a few days' practice with ball ammunition on a field-firing area.

The Auxiliary Forces would, as a whole, be a far more valuable

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asset to the nation, if they were enabled to become good mechanical shots on conveniently situated 30 yards ranges; and if judging distance, rapid aiming, and eyesight were improved by training on carefully prepared aiming grounds. In both these cases however accessibility is of the first importance. A man who is working for his living may be able to spare pretty frequently one or two hours in the evening without detriment to his business; but the giving up of a whole day, or even of an afternoon, is a far more serious matter, and may entail considerable pecuniary loss to the business man or loss of his situation to the labourer.

It may therefore be deduced that the following types of range are necessary :—

(*a*). The *30 Yards Range*, in sufficient numbers and so sited as to be easily accessible for every man, whether of the Regular or Auxiliary Forces, to attain mechanical perfection of firing.

(*b*). *Aiming Grounds*, to be both numerous and easily accessible, and which might possibly be sited in conjunction with the 30 yards ranges.

(*c*). *Field-Firing Areas*, as described above, with hut accommodation, on which the Regulars can be efficiently trained in firing under service conditions and on which the Auxiliary Forces can have a modified training.

Classification Ranges are desirable as an intermediate step between the 30 yards range and the field practice range; but, provided that conveniently situated 30 yards ranges and aiming grounds are available, they are not absolutely essential. Since, however, a few of these ranges can as a rule be sited on a large field-firing area without detriment to its use for field practices, and at no expense other than for construction, they should when possible be supplied, in order that the individual may be able to test the sighting of his rifle within the limits of decisive ranges and that the good shots and N.C.O.s may obtain some knowledge of weather conditions.

CONCLUSION.

It is therefore evident that the provision of small classification ranges, having the minimum danger area allowed by regulations, is not in the true interests of either economy or efficiency having regard to :—

(*a*). Their cost as compared with the 30 yards range.

(*b*). Their inaccessibility as compared with the 30 yards range.

(*c*). The fact that they provide no training whatever in fire observation and control, a subject which in war between first-class powers is of the first importance. It is a matter of common knowledge that a well-drilled number of medium shots under a capable fire leader will produce far better results in collective fire than an equal number of skilled shots under an inexperienced or incompetent fire leader.

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(*d*). The fact that they provide no training for the individual soldier in shooting under service conditions. This is a subject which in war between first-class powers is second only in importance to the training of the fire leader, and which in our smaller expeditions is of perhaps greater importance.

(*e*). The fact that the training of the fire leader in fire observation and control under service conditions is of far greater importance than a knowledge of wind and weather conditions obtained on a classification range, which knowledge, though it may help to win prizes at Bisley, will be of little value on service.

Also it cannot be denied that, if the United Kingdom were at war with a first-class power, there would not be time available for training fire leaders. All that could be done when war had been declared would be to partially train the masses of auxiliaries who would be required in the purely mechanical processes of shooting.

Now field-firing areas cannot be provided in a few days, nor in a few months; on the other hand 30 yards ranges and aiming grounds can be provided comparatively quickly. Therefore any comprehensive scheme for the provision of rifle range accommodation should deal with the requirements of the nation in the following order:— firstly as regards field-firing areas, secondly as regards 30 yards ranges and aiming grounds, and lastly as regards classification ranges and these only where they can be provided at a reasonable cost.

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TRANSCRIPT.

SAPPING AND MINING WORK BY THE 1ST COMPANY, 17th SAPPER BATTALION, AT MUKDEN.*

Position of the 3rd Infantry Division.

THE 3rd Infantry Division, to which Captain Ter-Akopov's Company was attached, took up, at the beginning of November, 1904, the portion of the Shaho position which extended from the railway embankment (inclusive) on the east to the village of Sifontai on the west. To the east (or left) was the 35th Infantry Division and on the west (or right) the 5th Army Corps.

The main line of defence lay along the line of the villages Ingoa and Sifontai, about a mile north of the river. But there was in addition an advanced line, extending from a point on the river bank about 200 to 250 paces west of the railway bridge, through the northern outskirts of Linshinpu (where there was a *point d'appui* called Fort Resurrection) and thence westwards in approximately the same direction. The only support to the left flank of this line was the so-called Bolkhov redoubt, which consisted of two lines of rifle trench meeting at right angles, the one facing the river at a distance of 180 paces, and the other facing the railway embankment, which at this point varied in height from 21′ to 35′, at a distance of 90 paces.

The Japanese Position 13).

On the eastern side of the railway the Japanese occupied the north bank of the river. They had seized the Fir Copse, and had constructed there a lunette surrounded by obstacles which approached within 100 paces of the embankment at a point 70 to 80 paces north of the bridge-head.

(11) and (12).

At the bridge itself they had excavated in the embankment a gallery with loopholes enfilading the Russian trenches, and somewhat further to the north they had built on the embankment a casemate of rails. They were able each night to extend their hold on the embankment northwards by excavating in its eastern slope recesses for riflemen, which commanded all the ground lying between the main and advanced positions of the 3rd Division.

To the west of the railway they held the left bank of the river, and from the bridge to Linshinpu the distance between the hostile lines increased gradually from 135 to 400 paces, which latter distance separated the Japanese in the Temple from Fort Resurrection. Beyond this the Japanese line was drawn back gradually to 1,200 paces from the Russians, the country here becoming completely open and level.

* From an article by Capt. V. Ter-Akopov in the June and July, 1906, numbers of the *Eenzhenernee Zhoornal.*

The numerals and letters in the margin refer to the map.

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For defence the Russian advanced position was entrusted to one complete regiment. It was decided that, in case this position had to be evacuated, the regiment should retire through the obstacles of the main position and rally as a reserve in rear of the remaining troops of the Division who were occupying the works on this line; but the task of arranging such a retirement and deciding on the exact moment for opening fire from the main position in night time proved exceedingly difficult. Russian Arrangements for Retiring from Front Position.

With a view to facilitating such a retirement, the Sappers, on the night of 10th—11th November, made a trench for one company on both sides of the railway half-way between the bridge and Ingoa, a connection through the embankment, and a communication trench from Ingoa leading along a ditch on the west side of the railway. The "Intermediate" Trench (1).

When the working parties were extended on this line the Japanese discovered them, and, anticipating an attack on the bridge, they lit beacon lights and brought up guns which opened a heavy fire on the Russians. But in spite of some casualties the latter stuck to their work and finished it successfully in the single night.

About the middle of November General Orlov took over command of the 3rd Infantry Division, and forthwith turned his attention to the difficult problem of retirement. It was decided that the advanced position should for the future become the main position, and that in case of attack it should be reinforced by the troops of the original main position, which should henceforth be considered only a rear one. Reorganisation of the Positions.

In support of this arrangement the line of the 35th Infantry Division on the left flank was pushed forward until it became roughly a continuation of the "intermediate" trench; but it still remained about 1,000 paces in rear of the left of the newly appointed main position of the 3rd Infantry Division, and the condition of this flank was felt to be very precarious. If the Japanese should concentrate by night a large force in their Fir Copse lunette, rush over the embankment, and fall on the rear of this flank, the 35th Division at that distance, and defiladed as they were from view by the high embankment, could do nothing to stop them. Consequently it became evident that the power of retaining the advanced position during the winter depended entirely upon whether this flank could be made strong enough of itself to resist attack.

With a view to enfilading any attacks made by the Japanese on the rear of the threatened flank, another one-company trench was made on the night of the 5th—6th December. This trench was sited entirely on the west side of the embankment, half-way between the "intermediate" trench and the bridge. The work was carried out under incessant fire from the Japanese casemate on the embankment. The "Rear" Trench (2).

But as it was clearly evident that for the effective defence of this flank some arrangement must be made to command the eastern side of the embankment, a party was sent out, on the night of the 14th—15th December, from the north end of the Bolkhov redoubt to commence tunnelling through the embankment at that point. During this and the three succeeding nights they completed the passage, and with the help of flying sapwork of sandbags they made a trench like a tambour for 20 riflemen on the east side of the railway. This trench was subsequently The First "One-Day" Trench (3).

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(4). connected with the Bolkhov redoubt, but at first its garrison could only be relieved by night, and for this reason it received its name of the "one-day" trench. It was situated 100 paces north of the nearest Japanese rifle recess, 200 paces from their rail casemate, and 360 paces from the head of the bridge, these distances being accurately estimated from the telegraph poles which were 70 paces apart.

Attack on the Casemate. On the night of the 19th—20th December, under cover of the fire from the "one-day" trench, a party of volunteers succeeded in rushing the rail casemate, which the Sappers forthwith demolished to its foundations.

The Sap on the Embankment (5). But the "one-day" trench, although very effectively situated, was considered too small, and in case of attack a very high standard of courage and devotion would be required from its 20 defenders. It was consequently decided to bring the eastern face of the Bolkhov redoubt up to the top of the embankment by driving a sap from the "one-day" trench southwards along the embankment. This was begun on the night of the 23rd—24th December, the trench being given in plan a special zigzag form to enable it to bring both the head of the bridge and the eastern side of the embankment under heavy fire.

The work was carried on day and night in spite of great difficulties caused by the rails and sleepers, the frozen state of the ground, and the incessant opposition of the enemy, who, in addition to their magazine fire, were able to bombard the work with shimoze shells from guns mounted in caponiers on the southern bank of the river. In spite of heavy casualties the sap proceeded uninterruptedly, and as each section was finished it was manned with riflemen. Damage done to the works by day was repaired by night. By the 24th January the trench had advanced 80 paces along the embankment, its length along the zigzags being not less than 150 paces, so that by this date a whole company was accommodated in the sap and "one-day" trench.

Flying Sap in Line with South Face of Bolkhov Redoubt (6). It had meanwhile become evident that the space of ground, measuring about 200 paces, between the head of the bridge and the left flank of the main position was insufficiently protected by fire, as the south face of the Bolkhov redoubt was partially masked by the trench in front of it. It was consequently decided to extend this face eastwards to the embankment by means of flying sapwork. After three days' preparation, during which 10,000 sacks were filled with earth, the Sappers, on the night of the 17th—18th January, began building up in the open the parapet of the sap under magazine fire from the enemy who were not more than 100 to 150 paces distant. Under such conditions the sap on the third night reached the embankment, considerable damage being done each day by shimoze shells to the sandbag parapet, which had to be repaired during the night.

The Second "One-Day" Trench (7). On the night of the 21st—22nd January this sap was prepared for infantry, and a mine gallery was begun running eastwards under the embankment, at the eastern exit of which a second "one-day" trench for 40 riflemen was completed by the 28th January. The difficulties of this work can be estimated when it is understood that the Japanese Fir Copse Lunette was only 70 to 100 paces distant from it, and nearer still

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the Japanese had posted concealed sharp-shooters who kept up a continual fire on the working parties and caused serious losses.

The Third "One-Day" Trench (8).

On the 29th January was commenced an exit leading from the gallery under the railway up to the surface of the embankment slightly to the north of it, and here was built another so-called "one-day" trench. From this trench fire could be brought to west, south, and east, and in the last-named direction it provided another tier of fire to assist the second "one-day" trench against the Japanese lunette; it was also found to be a good place for observing the effect of artillery fire. It is needless to say that the construction of this trench was carried out under very heavy fire from the enemy.

Offensive Saps (9).

With the construction of the above-mentioned works the defence of the left flank was considered complete, and the Sappers were set to work to prepare for an attack on the bridge itself. On the nights of the 27th—28th and 28th—29th January, moving out from the left flank of the front trench on the river bank, they constructed a trench by flying sapwork which reached a point about 100 paces west of the bridge-head; and on the night of the 6th—7th February, by the help of two sap-roller mantlets, they built a parapet of sandbags close to the west side of the embankment in front of the south face of the Bolkhov redoubt and only 90 paces from the bridge.

(10).

During the construction of this last some Japanese, skirmishing up by ones and twos to a neighbouring fold in the ground, were preparing to rush the work, when they were discovered and exterminated by magazine fire. On the following night an attempt was made by the Sappers to dig a trench behind this parapet; but the ground being frozen hard and the enemy on the alert, they were driven back with heavy loss and obliged to discontinue the work.

The Mine under the Embankment (a).

As further progress by sapping was impracticable, a mine was started from the gallery of the second "one-day" trench, and was driven southwards day and night with the intention of blowing up the Japanese gallery at the head of the bridge. As soon as the mine reached the neighbourhood of the sandbag parapet just mentioned, a branch was started towards this parapet; by the 28th February this communication was finished and the mine itself had approached within 60 paces of the Japanese gallery.

Attack on the Bridge.

On the following night the attack on the bridge was carried out, but as the Sappers were busily employed elsewhere only 14 men of the volunteer section took part. The assaulting columns, having assembled in the saps and having received written and verbal orders, at 8.0 p.m. rushed the head of the bridge.

(b).

The Sappers burst into the Japanese gallery and made an exhaustive reconnaissance of all their works in the vicinity. They discovered that the Japanese had driven two mines northwards under the embankment, and that these were waiting ready charged until the Russian approaches should arrive within their sphere of action. Another mine, unfinished, was also found, running westwards from a ravine on the west side of the bridge-head; this one was intended to work under the left flank of the Russian trench. Having cut the leads of the charged mines the Sappers

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set to work to turn the captured works against the enemy, but the attack was not fated to be successful and the Russians were forced to retire after losing many of their number. The Sappers brought away as trophies some drills, a long pyroxiline cartridge, and some samples of the Japanese leads.

Mining Warfare at Linshinpu (16) and (17).

For the remaining few days during which the 3rd Infantry Division continued to occupy their positions on the Shaho, the Sapper work was confined to mining warfare; but before detailing this some account may be given of the mining in the neighbourhood of Fort Resurrection.

Japanese Mine to Fort Resurrection (*a*).

About the middle of January the outposts noticed that the Japanese were removing large quantities of earth from their post in the Temple at Linshinpu, and at times, when the weather was calm and there was little firing, underground knockings were distinctly heard. It became evident that the Japanese were driving a mine against the Fort, which was occupied by 1,000 men of the 9th Ingermanland Infantry. The Japanese mine ran almost due north, passing to the east of the fort, from whence a branch was driven which ran under its left flank.

Russian Counter-Mine (*e*).

On the 14th January the Russians commenced a counter-mine from the left end of the front face of the fort, running south-eastwards almost straight for the centre of the Temple. After proceeding about 180 paces, branch galleries were thrown out to the right and left and it was in the latter (or easterly) branch that the systems met.

On the night of the 27th—28th February the Japanese, evidently sounding for information, drove a drill, probably 14 to 20 feet in length, into the head of the Russian branch gallery. The Russian Sappers tried to break off the end of the drill, but failing in this they reported the occurrence and orders were given to charge the branch gallery as quickly as possible. From sounds heard in two casemates in the Fort it appeared that the Japanese were also charging their mine. The whole of the following day a very heavy bombardment continued, the Russians having commenced this as a preparation for their attack on the railway bridge. But the Sappers succeeded in bringing up 18 barrels, each containing about 92 lbs. of powder, and, working in a suffocating atmosphere from which many fainted, they succeeded in charging and tamping the mine. Everything was ready by 10.0 p.m.; permission having already been received, the mine was fired forthwith by a Siemens machine; and the Japanese mine was destroyed, to the very great relief of the garrison of Fort Resurrection.

(*c*).

On the 1st March, as a result of the information received during the assault on the bridge, a shaft was sunk from the eastern end of the front trench, and branch galleries were begun, running north, east, and south, to counteract the enemy's action in those directions. The mines at Fort Resurrection and on the railway were also pushed forward.

But on the 3rd March orders were received to charge all the mines as enormous fougasses; and on the night of the 5th—6th March, after all the remaining troops had retired, they were fired by the Sappers, who thereupon abandoned the position, which, at the cost of 27 per cent. of their numbers, they had done so much to render impregnable.

F. E. G. SKEY.

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REVIEWS.

APPROXIMATE ESTIMATES: A Pocket Book for Estimating.

By T. E. Coleman.—(E. & F. N. Spon. Price, 5s. 3d., post free).

This is the third edition, revised, greatly enlarged, and with an altered title, of Mr. Coleman's *Architect's and Engineer's Price-Book.*

It starts with general remarks on the preparation of estimates, including notes on the proportional value of labour and materials in each trade and the cost of an ordinary house by trades and by parts. A list of the various external services, such as approaches, paving, water supply, etc., which have to be thought of in making an approximate estimate, might have been added with advantage.

Next come remarks on the execution of works, with tables of the average current rates of wages per hour of tradesmen in London and the country, working hours, payment for overtime, and average prices of building materials.

The bulk of the book (400 pages) consists of an alphabetical list of average prices for all sorts of building and engineering works, by unit, cube, square, foot-run, and otherwise. In many cases the actual costs of works recently executed are given. Comparing the rates given for various Barrack buildings with the average costs of those erected between 1897 and 1905 under the Military Works Loan, we find the majority of the figures are decidedly low, but this may be due to Mr. Coleman's cube rates being calculated from the bottom of the foundations instead of from half way up them. For most military buildings it would be better to take cube rates from the *Synopsis of Cost and Construction of War Department Buildings*, which is to be found in all R.E. Offices.

But it frequently happens that approximate estimates are demanded at short notice of works for which few or no data are to hand and of which the estimator has had no experience. In such cases a book like this is of great assistance. Like all price books it must be used with discretion, but so used it will be found of considerable value.

The last 40 pages are taken up with miscellaneous building notes and memoranda. Equipped with Hurst's *Pocket Book*, Mr. Rea's *How to Estimate*, and Mr. Coleman's *Approximate Estimates*—all three written by gentlemen of the civil Staff for Engineer Services—Division Officers and Foremen of Works should have little difficulty in furnishing any estimates required.

A. M. Henniker.

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LES CHASSEURS DES VOSGES, ET LE PONT DE FONTENOY.

By LT.-COL. SAINT ETIENNE.—(Toul: Imprimerie Lemaire. Price, 3 frs.).

This is a very interesting description of the blowing up of the bridge at Fontenoy by franc-tireurs on 22nd January, 1872.

At the date of the Franco-German War there were three railway approaches to Paris:—

1. *Via* Mulhouse. This was defended by Belfort and Langres, and was never any use to the Germans.

2. *Via* the Ardennes. Defended by Montmedy and Mezières, and not cleared till just at the end of the war.

3. *Via* Strasbourg and Toul. This was the shortest and best route; and after the fall of Toul on 23rd September it was clear for the Germans as far as Nanteuil tunnel, which was blown up. Later, when this tunnel difficulty had been surmounted, the line was available right up to the lines of investment round Paris.

The three possible places for demolitions near Toul were the bridge at Fontenoy, a 7-arch masonry structure across the Moselle, and the tunnels of Foug and Pagny.

Pagny was never prepared for demolition. Foug was prepared at the last minute, but the workmen were interrupted by the Germans on 17th August before completing.

The bridge at Fontenoy had been prepared, when it was built, with a chamber for demolition in the first pier on the Strasbourg side; but the plans had been lost, and no one knew where the galleries were. They were discovered again in August by means of one of the masons who had helped to build the bridge 20 years before, and the arrangements were put in order.

The preparations were completed on 7th August, but the Commandant at Toul received orders that the bridge was not to be destroyed without direct orders from the Emperor. Such orders were never received; and though urged to do so, he refused to carry out the destruction.

On 2nd September the Commandant at Langres, 120 kilos. away, sent an expedition to destroy it. Too many men were sent, and they were slow in getting there, and on the news of Sedan they were recalled with nothing done.

On 23rd September a civilian expedition with powder started from Langres, but was stopped by the fall of Toul. The powder was buried in a wood.

Several plans were made after the taking of Toul, but they came to nothing.

On 9th November a Military Committee was formed, to act against the German lines of communication. They made their headquarters at Lamarche, a secluded village in the mountains. A very interesting account is given of the formation of a company of franc-tireurs, and the difficulties that had to be overcome in equipping them. A fortified camp of instruction was formed in the Forest of Boëne.

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By the end of December there were 300 men. They applied to the Commandant of Langres for powder, and, though refused for some time, obtained it by the middle of January.

The expedition started for Fontenoy on 19th January, and was completely successful, breaking down two arches of the viaduct. The previously prepared demolition chamber was discovered after some trouble; and the powder, 250 kilos. of which had been brought on 3 horses, was inserted down the shaft, which was large enough for two men to enter. The actual amount of powder used is not stated. There is an interesting account of the march to Fontenoy and the return by another route.

The Germans began to mend the bridge on 24th January, by filling in the broken arches with an embankment. Traffic was resumed on 4th February.

E. G. GODFREY-FAUSSETT.

OUR BIRTHRIGHT: AN ESSAY ON THE VITALITY AND RESOURCES OF THE NATION IN RELATION TO NATIONAL DEFENCE.

By 'OPTIMIST.'—(1s. Constable).

This essay was written before the publication of the recent proposals for the reorganization of our Auxiliary Forces. Its objects are, firstly, "to set before the country positive proof of the immense amount of material trained on a sound social as well as military basis which it possesses"; and secondly "to bring home to every one the possibility that this material can be so developed, by the existing great voluntary organizations which have created it, as to supply a present and effective substitute for universal compulsory military training."

The author considers that the entire future solution of the problem of sound National Defence on Voluntary lines lies in the extended support of the existing organizations. "This alone is the real and only safeguard against that militarism which may rightly be characterised as Defiance not Defence, and as carrying with it that hateful thing 'Conscription.'"

Unfortunately, he purposely does not attempt to deal with the question of the compulsory or voluntary military training of the adult manhood of the nation. And as to 'Conscription,' so far as we are aware, no responsible person has advocated for this country the adoption of conscription in its proper sense, that is of compulsory manhood military service which is by no means universal and which entails hardships on many classes; what has been urged is compulsory universal military training on the threshold of manhood.

In his introduction 'Optimist' makes a statement which covers the solution of the whole question of National Defence—

"It is no longer a debatable matter, it is a recognised fact, that the *outer* guardians of our islands are our sailors and our ships of war; but it

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is strongly taking hold of the public mind that the *inner* defenders of our homes ought to be found not in our Regular Army but in our citizens, properly trained, organised, armed and equipped. Our soldiers are required for the defence of the Empire, our citizens for the defence of our homes."

He shows how at various epochs in the past the right, as well as the liability, of every citizen to serve in defence of his country has not only been acknowledged but put into practice; and he gives a most interesting summary of the origin, history, organization, methods, and achievements of various Voluntary Official Bodies and Voluntary Civil Bodies.

Amongst the Official Bodies he includes the Yeomanry and Volunteers, uniformed Cadet Battalions and School Cadet Corps, the Duke of York's Military Schools, un-uniformed Cadet Corps, and Rifle Clubs. Amongst Civil Bodies he includes the Telegraph Messenger Lads, the Boy Messenger Company, Church Lads' and Boys' Brigades, the Polytechnic Society, the Y.M C.A., Dr. Barnardo's Homes, the Salvation Army, the Church Army, Industrial and Reformatory Schools, and Working Boys' Clubs and Homes. He shows that during the last 45 years some 2,000,000 men have passed through the Volunteers and over 2,000,000 boys through the other institutions, and that therefore over 4,000,000 have "voluntarily received instruction in military drill, physical training, and shooting of a regular or modified description." He therefore succeeds in carrying out his first object; but, since it has been acknowledged that the present training of the Volunteers is insufficient to enable them to contend with the trained forces of the Continental Powers, 'modified' is a somewhat generous term to apply to the training of the members of some of the other Bodies mentioned, and in these latter it is doubtful whether the training has not been undergone as a result of 'peaceful persuasion' rather than as a strictly voluntary act.

To effect his second object 'Optimist' divides a boy's life into three phases;—(1) from birth to 5 years; (2) from 5 to 13; and (3) from 13 to 19, the ages given for the upper and middle classes in the two last phases being somewhat greater.

The care and development of the child in the first phase can, he thinks, be left to the National Health Society and the National League for Physical Education and Development.

The moral, mental, and physical training of the working-class boy from the time he enters an elementary school till he leaves it as a wage earner, and of the higher class boy from the time he enters a preparatory school until he leaves it for a secondary one, can be carried out under the instructions of the Board of Education. It is said, no doubt with truth, that military training under 12 years of age is more likely to do harm than good.

The physical and modified military training from 13 or 14 years until manhood may be effected through the various uniformed and un-uniformed Cadet Corps, Clubs, etc., already mentioned. The difficulty in the matter is in connection with the working-class boy, and the author thinks the solution lies with an extension of Working Boys' Clubs in towns and the formation of Cadet Branches in rural districts. He suggests that it

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should all be done on voluntary lines under a Central Committee in London, without State supervision, and without State aid other than capitation grants for efficiency, the free issue or loan of arms, ammunition, and camp equipage, and permission for officers to attend military schools of instruction; but all this means money. The crux of the problem is the officering of the boys; and in this connection the author remarks that "the man of the well-to-do classes, between the ages of 20 and 40, as a rule will not give up his leisure to performing any work which smacks of duty and in the carrying out of which he is brought under any form of discipline."

To our understanding 'Optimist' does not succeed in effecting his second object. He indeed shows that the various organizations directly or indirectly provide a considerable number of recruits for the Regular Army; and "afford such elementary military training as will fit their members to become more useful and efficient citizens," and to be more easily convertible into soldiers, than they otherwise would be. But he perpetuates the existing anomalous system under which the defence of the country is undertaken by a small number of patriots at considerable expense and inconvenience, whilst the great majority of citizens wilfully and even ostentatiously neglect their first duty. He does not show that much of the monetary support voluntarily given to the above-mentioned organizations would not be better spent, as a matter of personal and national insurance, in the form of an additional tax for the purpose of covering the cost of really universal training. And he does not prove that these voluntary organizations would be less costly than or an *effective* substitute for compulsory military training.

Since the experience of other countries has conclusively shown that compulsory military service improves the nation both in individual physique and in collective industrial efficiency, and since the majority of our military experts are convinced that compulsory universal military training is the only means by which the Regular Forces of the Crown can obtain that power of expansion which is essential if they are to wage war successfully with any of our rivals, it seems almost a pity that the institution of such training should be delayed by a few patriots volunteering for modified military service and by 'Optimists,' even with the best intentions and with justice, applauding them for doing so and attempting to prove that this patriotism by proxy renders such training unnecessary.

A. T. MOORE.

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NOTICES OF MAGAZINES.

Bulletin of the International Railway Congress.

February, 1907.

Lock-Nuts.—The simplest and most extensively used contrivances for preventing the working loose of nuts are the ordinary lock-nut, the split pin, and the Grover washer. All of these are more or less unsatisfactory because they do not attack the real cause of working loose of the nut, which, a little paradoxically, lies in its inertia and the couples set up by vibration.

The lock-nut acts by forcing its lower thread against the upper thread of the nut proper; but the usual shape of the lock-nut only enables it to utilise a very small portion of its possible useful effect.

After considering the various other systems, we come back to the lock-nut, and enquire whether its design cannot be improved so as to eliminate its faulty features.

The type advocated embodies:—

(1) reduction of the faces in contact so that only those parts bounded by the diameter of the thread are in contact,

(2) reduction of the total diameter to minimum, so that less energy is imparted by the vibration to the lock-nut than to the nut proper, and consequently any working tends to tighten the contact between the faces.

The design proposed is in fact bevelled off on both faces, and the working face is cut at a slope to the axis (not at right angles), so that one side of the working face only is screwed up into contact with the nut proper.

C. E. Vickers.

Engineering News.

February 7th, 1907.

Design of Railway Freight Terminals.—While this paper considers mainly the design of large yards calculated to handle a great volume of traffic, it is worth reading as enunciating clearly several important principles in design. It must not be forgotten that both the cost of and time occupied in shunting depend on how the yard is laid out.

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The bulk of the work in a goods yard is the separating or classifying of trucks ("sorting"), second to which comes the arrangement of trains in station order ("marshalling"); and besides this independent sidings have to be provided for wagons held for orders (*i.e.* to be reconsigned) as is commonly the case with coal traffic, for empties, for damaged vehicles, etc. Any one yard is generally best used to handle traffic in one direction only, up or down; and if traffic for more than one district is to be handled, the first stage of separation would be to send to the appropriate yard.

Again, there are at least two or three different ways of shunting, by "kicking off," by "poling," or by gravity—either "hump" arrangement or by running down from a natural inclination.

The receiving yard should be of sufficient length to accommodate the maximum length train plus a certain amount of leeway for double-headed trains and for pulling up; but too long sidings mean difficulty in handling by the shunting engine.

It is advisable that the "sorting" of a train should be accomplished in one operation as it is brought into the sorting yard; the "poling" method has many advantages for doing this, but requires that the ladder tracks should branch off a straight. On the flat the marshalling must be done by push and pull, but in a gravity yard the wagons can be lowered out so as to assemble into the departure tracks in station order.

The exact position of the weighbridge is a matter needing careful consideration. On the whole it seems best not to put the weighbridge on a line by which trains regularly enter, but to site it on an independent line, into which "weigh" cars can be shunted until a convenient number are got together, and then they can be pushed successively over the bridge and subsequently taken back to the sorting sidings. In the same way the transhipment shed had better be located alongside an independent line.

It is important that yards should be well lighted, particularly at the head of the sorting sidings; and there should be sufficient light to allow of cars standing on any line being seen sufficiently clearly to ensure the cars entering being braked down in time. Reflectors to electric lights, so as to cast the rays in the proper direction without dazzling, are suggested.

C. E. VICKERS.

ENGINEERING RECORD.

February 2nd, 1907.

TREATMENT OF CONCRETE SURFACES.—A paper read by Mr. L. White, Engineer of the South Park Commissioners, Chicago, discussing methods of obtaining a suitable surface finish to concrete work. Concrete is now being used extensively for the fronts of buildings and for architectural mouldings as well as for pavements, balustrades, drinking fountains, and so on.

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The author remarks that surface defects are due mainly to (1) imperfectly made casings, (2) badly mixed concrete, (3) carelessly placed concrete, (4) efflorescence and discolouration of surface. Lining the casing with sheet metal or oilcloth has not been found much use. Two methods suggest themselves:—treating the surface to correct the defects, or using for surface finish a mixture which will not take the imprint of the casing and will minimise rather than exaggerate surface defects and will not effloresce.

Besides these, various methods of treatment by tooling, scrubbing, etc., have been proposed, all having the object of removing the outer skin of mortar in which the surface defects exist. The author has tried what he calls the Acid Treatment. Dilute acid (presumably hydrochloric) is used as a wash to remove the cement and expose the stone and sand, then an alkaline solution is applied, and finally a wash of water. Obviously the treatment is inapplicable where a limestone aggregate is used. It is not stated how the removal of the cement skin is expected to affect the subsequent weathering of the finished surface.

C. E. VICKERS.

MITTEILUNGEN ÜBER GEGENSTÄNDE DES ARTILLERIE-UND GENIEWESENS.

February, 1907.

THE RUSSIAN ENGINEERS.

1. *Organisation and Training.*

The present organisation dates from 1894. The duties comprise:—fortification of positions; co-operation with other arms during the attack of a position; construction and demolition of roads, bridges, etc.; and the attack and defence of permanent fortresses.

In peace time the Sapper Battalions, consisting of 3 Sapper Companies and 1 Telegraph Company, are massed in brigades to facilitate training.

In war one battalion is posted to every Army Corps. One Sapper Company belongs to each of the two Infantry Divisions, and the third is at the disposal of the Corps Commander.

The war strength of a Sapper Company, which appears to correspond with our Field Company, is 4 officers, 20 N.C.O.s, and 200 sappers, with 2 trumpeters; and in addition 16 men belong to the Company Train.

The Train consists of 16 wagons divided into a technical train and a baggage train. The technical train (9 wagons) is composed of 1 four-horse team, 2 three-horse teams, and in the Divisional Companies 6 six-horse teams for the bridging material. The baggage train consists of 1 portable field kitchen, 1 two-horse ammunition cart, 1 officer's cart, and 4 more pair-horse carts.

The following tools are carried with the company:—100 shovels, 70 large pickaxes, 8 saws.

The technical train takes the reserve tools, sandbags, wire, instruments,

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320 kilograms of explosives, telephones, and a light bridge train for a bridge about 65 feet long (2 trestles, 4 half-pontoons, 20 baulks, 105 chesses).

The baggage train carries two days' rations (biscuits, corn, salt, tea, sugar, and preserved vegetables); also 30 rounds for every rifle, and the officers' baggage.

The company is organised in 2 half-companies.

The technical training is mostly accomplished during the winter, and the following annual courses are arranged :—

(1). A Field Engineering Course for young N.C.O.s.
(2). An Advanced N.C.O.s' Class.
(3). A Course of Demolitions.
(4). A Railway and Mining Course.

The practical training in summer is as follows :—

(1). *Company Training*, when field fortification, placing obstacles, and making camps are practised.

(2). *Battalion Training*, when bridging is carried out, and also mining and railway work by the special units detailed for this work.

(3). *Brigade Training*, when the attack and defence of positions are practised.

(4). *Manœuvres.*—During the manœuvres the companies are attached to their respective Divisions and carry out any work that may be ordered.

The recent war showed that the previous organisation was not altogether satisfactory, and that it was desirable to hand over the battalions to their various Corps during peace.

2. *Tactical Employment.*

The most important works with which the Russian sappers are concerned are the construction and restoration of roads and bridges, the demolition of the same, the fortification of positions, and co-operation in attacks on fortified positions.

(*a*). *Roads and Bridges.*—The restoration of roads and bridges destroyed by the enemy is particularly important in order that the troops may not be delayed in their advance.

During the last war, there were many occasions on which the Sappers had to carry out this work during halts or by night, and then had to continue their march the next day without any rest.

In order to save time as much as possible, the Sappers should be sent on in front as far as circumstances permit. The greater part should be detailed to the advanced guard, so that this part can be pushed forward with the mounted troops during a halt in order to carry out any work that may be necessary, the remainder staying with the main body or transport train.

Thus a company is usually divided as under :—

½ company with advanced guard.
1 section at the head of main body.
1 section at the head of the transport column.

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As regards bridging a Russian Sapper Company makes pontoon, temporary, or permanent bridges. With their bridging train they can bridge a gap 16 to 20 yards wide with 4 N.C.O.s and 24 men in 20 minutes to ½ an hour. Their field bridges are made from material obtainable in the vicinity. Permanent bridges are only constructed when the bridge is required for a long time and has to take every sort of traffic

(*b*). *Destruction of Roads and Bridges.*—Complete destruction of roads or bridges is only undertaken on the express order of the Commander-in-Chief.

Such work is generally done by the railway and demolition detachments, which form part of every company. The Field Troops attached to the Cavalry and Cossack regiments of the Warsaw and Wilna Districts are of great value for these services.

(*c*). *Fortification of Positions.*—Colonel Anisimof, the author of this article, lays down the following principles for the fortification of positions:

"Every position in defence, and every position captured during the attack, must be at once strengthened by artificial means.

The troops must invariably be capable of carrying out without assistance from the Sappers any work in connection with temporary field defences."

He further lays down that the only way to obtain success with the minimum loss is by the closest co-operation of rifle, spade, and bayonet.

In hasty defences, when the maximum time available seldom exceeds 24 hours, every minute is of importance.

He states, as the general experience of the Russian Staff during the last war, that the Sappers were not generally at hand during the advance against a position, and that the troops must not expect that help from them will be available.

On such occasions only the simplest type of trench for infantry and artillery will be attempted, and where it is a case of defence improvised obstacles and very simple defence works must suffice.

The knowledge and experience necessary for these works must be acquired by the troops in peace.

Colonel Anisimof declares that the foundation of this peace training for officers and men must be a firm conviction of the supreme importance of artificial cover.

The Russian *Manual of Field Fortification* lays down the following as the duties of individual officers.

The Commanding Officer of a Regiment inspects the position, and issues his orders as to the duties of the different battalions; he decides the general alignment of the trenches and the position for the batteries and reserves; he also determines the defensive measures to be adopted for isolated points and the arrangements for communications.

He inspects the ground itself and not the map only. He should be careful not to issue his orders from the map and then ride over the ground, as by this method a great deal of work already accomplished will be rendered useless by subsequent alterations.

He must avoid going into detail, as this prevents his subordinates from learning to adapt themselves to time and circumstance, and the training is then of doubtful value.

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The Battalion Commander directs the work of his own command.

He carefully supervises the direction and position of the trenches, which he brings into the proper relative position with the trenches of the neighbouring section and with the battery positions in his own section.

The Company Commander, after having obtained from the Battalion Commander the general line of the trenches, must be able to select at once for any portion of those trenches the most advantageous position.

At present in Russia 1 officer and 4 men from every Infantry Brigade are attached yearly for two months to the Sapper Brigades, and they should then be able to organise and supervise the fieldworks of their own troops.

Their numbers and the duration of their training should however be considerably increased. Then and only then will the infantry be able to carry out thoroughly the hasty field defences which will fall to their lot.

If under exceptional circumstances there are any Sappers unemployed in a section, they will be sent to other sections and come under the commander of that section.

In any section of the defence, the Senior Sapper Officer acts as section engineer, and it is his duty to bring to the notice of the Commanding Officer of the Section any irregularities or mistakes in the works under construction. The Sappers will usually be employed on the more difficult work, such as erecting obstacles, etc., where their special training is of most value.

At the battle of the Yalu the Russians were in dire need of engineers. There was not a single Sapper in the whole detachment. The consequence was that, in spite of General Kuropatkin's express order that the whole of the time available (1 month) should be devoted to fortifying the position, the only works executed were trenches for kneeling and standing fire and some slight cover for the artillery.

When the troops, or civil labourers, are employed in putting a position into a state of defence, all the Sappers are absolutely necessary for purposes of supervision. Their actual manual labour should be confined to bridging, mining, making abatis, etc.

(*d*). *Attack on Fortified Positions.*—The Russian Sappers are used to give technical aid to the troops in overcoming obstacles.

The artillery fire begins the destruction of the obstacles, and facilitates its completion. The Sappers overcome obstacles by demolishing them with explosives, removing them by hand, or surmounting them by bridges; and combination of all three methods is advisable.

The Sapper detachment detailed for this work follows immediately behind the skirmishers, who take up a position in front of the obstacle and with the help of machine-guns try to keep down the fire of the defence.

As the issue of the entire attack often depends on the success of this very important and difficult work, it is necessary that the best men should be taken and placed under the command of a cool and determined officer; and they must devote all their intelligence, courage, and inventive powers to overcoming the obstacles that bar their way.

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Having effected an entry into the work, the Sappers must at once search for the leads which may be in connection with a mine in the work itself; when found these leads are at once severed. Then they proceed to strengthen the work against counter-attack.

The execution of such tasks as these, under a deadly fire, without a moment's hesitation, can only be entrusted to a special corps, which is highly trained in peace time and is animated by the highest *esprit de corps* and by patriotic devotion.

IMPROVISED EXPLOSIVES AT PORT ARTHUR.—In the August, 1906, number of the Russian Engineer Journal, in an article entitled "Samson, an American Explosive Material," it is stated that a new explosive was manufactured in Port Arthur during the siege. It was used with great advantage for filling hand grenades, charging fougasses, and carrying out other demolitions.

This explosive was made of constituents the nature of which was first discovered by the Russians in September, 1906. The raw material consisted of a fine white powder, known as kali, and a dark brown gelatinous oil, known as "the fluid." The chemical composition of these two substances is a secret, but it is supposed that the powder called "kali" was a form of potash.

The description of the properties of the constituents and of the preparation of the explosive, as also the qualities of the latter, serve however to show that it probably consisted of potassium chlorate with some organic substance such as petroleum residue, and some added carbon; and that it was a compound similar to "rackarock," which consists of 79% potassium chlorate and 21% of nitrobenzol.

The preparation of the final material had to be carried out very circumstantially. The potassium compound had to be powdered and sifted; then the constituent parts were carefully weighed out in a special room, 3 or 4 parts of the potash salts to 1 of the "fluid"; and finally the constituent parts were mixed together by hand, gloves being worn for the purpose.

The resultant explosive, which cannot be recommended if exposed to damp, is liable to be fired by friction, spark, or flame; and its use is therefore attended with some danger.

It develops an explosive force somewhat greater than black powder. To obtain the best effects for blasting purposes it must be well rammed into the hole, but not much tamping is necessary.

Chinese shells filled with "Samson" explosive were burst into smaller fragments than when black powder was used.

Potassium chlorate, with the addition of some organic substance, has long been known as an explosive material, and its application to such purpose in war-time is always possible.

But of late years other compounds for the same purpose have been experimented with; and in view of the unpleasant and dangerous properties of compounds of potassium chlorate, it is not likely that extensive use will ever be made of "Samson" explosive.

C. OTLEY PLACE.

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NATURE.

January, 1907.

"PETROLEUM AND ITS PRODUCTS" (*p.* 218).—This book deals with the history of the petroleum industry from the use of bitumen in building the Tower of Babel down to statistics as late as 1904. The methods adopted for winning the crude oil in America, Canada, and Russia are detailed. The shale oil industry, being of British origin, is described. There is an able section on the transport, storage, and distribution of petroleum. The testing of crude petroleum and its many products and the fixing of the flash point at its present value are especially interesting. A full account is given of the beautiful method of testing for petrol vapour and other inflammable vapours in air, which depends upon the fact that a hydrogen flame of fixed dimensions, burning in air containing a small portion of inflammable gas or vapour, is seen to be surmounted by a small cap or halo, the size of which indicates the amount of inflammable vapour in the air, long before the mixture itself becomes inflammable. In these days when petrol is so largely stored, and when so many steamers are engaged in the oil trade, tests, capable of revealing any dangerous leakage of vapour, are of the greatest importance, and the "flame cap" offers a certain mode of detection.

"JUJUTSU," by Mrs. Roger Watts (*p.* 250), gives concisely and clearly an idea of this fascinating art. It is written with the idea that anyone having had a few lessons may continue the exercises, or throws, without the constant help of a teacher, though to learn, from the description only, would be quite impossible. Sir Lauder Brunton, writing a preface to the book, says: "By it not only is every muscle strengthened, but the highest centres of the brain are developed—those whose functions are perception, discrimination, and decision." The book contains 141 excellent illustrations; the photographer has most patiently caught the different positions, enabling the reader to follow the text. English wrestling is more or less a trial of strength, but "jujutsu" is a question of quickness and brains.

MARINE BIOLOGY (*p.* 251).—The results of active investigation, under the auspices of the International Council for the Exploration of the Seas round North Europe, record and endeavour to explain the constantly changing physical conditions under which fishes pass their lives, as well as a detailed knowledge of the various smaller marine creatures which serve as their food. The whole story of the life of the common eel, as now made clear by these investigations, is one of the most fascinating which it has fallen to the lot of any naturalist to reveal. We can picture the great shoal of parent eels, the long journey from the inland waters ended, arriving at their proper spawning places in the deep Atlantic; the floating eggs gradually developing into transparent, deep-ribbon-shaped Leptocephali; the slow transformation to slender, active elvers; the vast

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multitude of elvers, foodless, moving steadily in towards the coast, entering the rivers; and finally the feeding and growth of the eels all over the European continent in preparation for the return migration to the sea.

THE SOLAR RADIATION (*p.* 326) is determined by allowing a beam of sunlight of known cross-section to shine upon a known weight of water for a known length of time and measuring the rise of temperature. The observations at Warsaw showed that between December, 1902, and February, 1904, the radiation was abnormally low as compared with the mean for the years 1901–5. This phenomenon has been noticed by several observers and is supposed to be due to the large amount of volcanic dust in our atmosphere.

THE RECENT HIGH BAROMETER.—On January 23rd at Riga the reading was 31″·58, at some of the stations in the British Isles it stood at 31″·1, being higher than any previous record. At Irkutsk on 20th December, 1896, it reached 31·72 inches. The lowest reading in our Islands was 27·33 inches at Ochtertyre on 26th January, 1884.

February, 1907.

ASTRONOMICAL CLOCKS (*p.* 353).—The accuracy with which these are now regulated is very interesting. Bradley in 1758 used a fairly accurate clock for his star catalogue, but this has been much improved on by enclosing the clock in an air-tight glass case, mounted in a vault where the temperature is kept constant, the pendulum being of nickel-steel.

Mean Deviation of Daily Clock Rate.

Clock.	Date.	Mean Deviation in Seconds.
Bradley's clock in	1759	0·102
Greenwich Observatory	1850	0·149
Greenwich Observatory	1900	0·051
Berlin Observatory	1877	0·030
Leyden Observatory...	1900	0·028
U.S. Naval Observatory	1904	0·015

SCIENCE IN INDIA (*p.* 403).—Major Lenox-Conyngham's report on the pendulum observations in 1904 for determining the force of gravity is interesting. He used "half-second" pendulums, which are only one-quarter the length of those previously used in the department. A new method has also been introduced for registration of the coincidences of beat between the free pendulum and the clock pendulum, the pendulums being no longer swung in vacuo. A considerable increase in accuracy of observation has thus been assured. Corrections have been applied for the minute vibrations of the stand on which the instrument is fixed, due to the swing of the pendulum. Some of the results are curious; for instance, it was found that at Calcutta the perpetual tremor, set up by the traffic, due to the nature of the alluvial deposits on which the city

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may be said to be floating, absolutely negatived the value of the observations, while, on the other hand, observations taken at Colaba in Bombay were not appreciably affected by the firing of the big guns of the fort in their vicinity.

Amongst the most interesting records of the season are the results obtained by a careful re-computation of Capt. Wood's observations for determining the position of Everest and other high peaks in Nepal. The difference, however, never amounts to half a second of arc, but the corrections in altitude of the peaks observed, due to the employment of a revised co-efficient for refraction, are more marked. The height of Mount Everest is reduced by about 300 feet, 28,700 instead of 29,002 feet. This, however, must not be accepted as a final determination, as there are other factors in the computation of altitudes, observed under extraordinary conditions, still to be determined with more vigorous exactness.

W. E. WARRAND.

RIVISTA DI ARTIGLIERIA E GENIO.

January, 1907.

NOTES ON IMPROVISED FORTIFICATIONS.—By Capt. Cardona of the General Staff.—Field fortification in the last century has seen an important evolution in military progress, whilst in the past centuries it had remained almost stationary. With regard to this we may note that Napoleon I. had affirmed "The principles of field fortification have need of improvement; this important branch of military art has not made any progress since ancient times; it is to-day lower than it was two thousand years ago; it is necessary to encourage the military engineers in this branch of their art, and to bring it to a level with others."

Until the adoption of arms of precision (about the middle of the last century) field fortification had made little progress; while in the latter half of the same century we find a continual adaptment of fortifications to resist the greater effects caused by the successive improvements in guns and rifles, characterised by the adoption of breech loaders, quick firers, especially weapons of small calibre, and smokeless powder.

In face of the old muskets and rifles of large calibre that were in use in the wars from '48 to '85 the value of entrenchments rested almost entirely on their obstacle ditches, because, the fire being of little effect, recourse to the bayonet became an absolute necessity.

The trenches were constructed with the idea of stopping the assailants, and throwing them into confusion by means of deep ditches, and the great quantity of earth taken from these found a natural use as a covering mass. This, while it served the purpose of stopping the projectiles of the enemy's artillery, had the defect that it was greater than was necessary to

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resist the penetration of the bullets fired from the afore-mentioned weapons and also that it was very visible.

In these wars the construction of land defences involved a slow and laborious operation. It is true that since the war of the American Secession there has been introduced the use of relatively hasty entrenchments in order to repair rapidly the effects of the enemy's fire; yet, in some armies there was for many years a lack of light sapper tools, so that the type of hasty entrenchments was not largely brought into use.

With the adoption of smokeless powder, rifles of small calibre, and modern artillery the fire has become more rapid, exact, and destructive, so that it generally suffices to decide the victory; and now it is necessary both for the assailant and the defender to seek cover from the effects of the fire by means of natural and artificial defences. These last should be of an altered character, since it is sufficient to provide protection from the enemy's fire while in former times it was necessary also to protect against shock. The artillery now seem to be abandoning the practice of firing with shells against the parapets of the trenches, because these are slight and invisible and the fire of shells against them does not warrant the enormous consumption of ammunition.

It is evident that the construction of improvised fortification, although it may be as it were a monopoly of the engineers, will form part of the duties of every arm, though the more difficult work may be reserved for the engineers.

It is not credible that the rôle of the engineer should lessen in importance on the battle field—quite the contrary. It is now, even more than before, his duty to display his proper activity in the entrenching of special positions, in improving the communications, in the construction and destruction of bridges, etc., and for such works a company of Sappers to each division would not be too much.

These facts have proved the forecasts of the writers who approve of the new methods of fortification. In the recent Anglo-Boer and Russo-Japanese wars, in which improvised fortifications were greatly developed and were more rationally used than formerly, the Boers and the Russians accomplished wonders in the sphere of active defences; and the Japanese, again, obtained from fortifications a greater power for the offensive, finding that, whilst somewhat impeding the movement of troops, they in no way lessened their aggressive spirit.

The transition from the old to the new methods of fortification has proceeded slowly and with some uncertainty, as has always happened in similar cases. It is precisely like everything else which offers great advantages if properly adopted and presents great inconveniences if badly used, that fortification is highly prized by many and condemned by not a few. The period of uncertainty however still continues, because we have not entirely abandoned the old ideas and we have not yet determined on the new ones. In fact there are still many who abhor fortification as being a grave hindrance, especially in the matter of tactics, being antagonistic to the free employment of troops. Others, while recognising that fortifications are indispensable, have doubts as to the method of

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employing them. However, notwithstanding the experience of the late wars, it has not yet penetrated into the minds of all that improvised fortifications are no longer a mere accessory but a principal element of tactics.

In most discussions and publications on the subject of fortification there are wanting abstract ideas on its essence and use. And it is precisely this want of unity which causes disagreement, as is especially shown in late years in which the old system of fortification has stumbled upon the new tactics. It is sufficient in fact to confront the ideas expressed by the Belgian Major Deguise in his work *La Fortification Passagère et la Fortification Mixte ou Semi-Permanente* with those of Colonel Rocchi in his *Traccia per lo Studio della Fortificazione Campale*, to recognise how widely different are the views of these two able writers, who have written on the subject within a period of only two years.

It now seems necessary that this uncertainty should cease, and we may be permitted to hope for the adoption of the issue of light sapper tools to the infantry.

The new phase of tactical evolution and new methods of fortification, as has been said, owes its origin to the introduction of smokeless powder and weapons of small calibre.

In 1891, in his treatise *La Fortificazione Improvisata*, the then Captain of Engineers Spaccamela, attached to the School of Parma, had abandoned the old scholastic methods formulated on the basis of geometry and grounded his instructions on the principle that improvised fortification should be recognised as a part of tactics. Spaccamela was one of the first in Italy to affirm that the construction of improvised fortifications should be the duty of infantry troops.

It was only after the Boer war that the military chiefs came to recognise the importance of improvised fortifications. The Russo-Japanese war gave to this importance an official sanction, and added the absolute necessity that tactics and improvised fortifications should be considered as parts of one and the same thing.

With regard to the evolution of field fortification, Deguise is of opinion that this owes its origin to the defensive organisation of lines of blockade, which followed the organisation of permanent fortification. It may be added that the latter system of fortification was renewed in the XVIth century owing to the influence of firearms. The above-mentioned author notes that the engineers of the XVIIIth century somewhat adapted their defensive dispositions to the times, believing it sufficient to modify the form of their works according to the improvements in weapons. It was only indeed from the adoption of arms of precision and of shrapnel that fortification could reasonably be associated with tactics, and in the war of the American Secession new forms of improvised fortification were introduced requiring little time in their construction and by their small dimensions not so much attracting the attention of the assailants.

A new phase in the evolution of fortification was developed towards the end of the last century, when ditches, placed in front of entrenchments to impede the assailants, became less necessary obstacles, because

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of the effective fire of arms of small calibre and also because smokeless powder rendered less apparent the positions occupied.

Deguise moreover affirms very justly that in fortification we cannot apply absolute formulæ, but that we should endeavour to make the character of the works conform with the various and complex tactical circumstances; for if we lose sight of the tactical idea, fortifications, which are otherwise useful, may become hurtful.

With regard to the influence that the progress of firearms has on fortifications Deguise notes very opportunely that the more the weapons become efficacious so much the less should become the visibility of the position, and that the masking of the entrenchments is essential.

He considers that a greater relief than 1·30 m. is unnecessary, and that only when the ground in front is open; and he advises a thickness of parapet of 4 to 6 m. in ordinary ground and 6 to 9 m. in clayey soil to resist the fire of field and heavy artillery.

With regard to the relation between the ground and the fortification Deguise affirms that it is necessary to study *the influence of the accidental topography with respect to the fortification.* He indicates the previsions to be made in various cases and dilates on the proper steps for defilading the work, especially in mountainous countries. In discussing the relations between the entrenchments and tactics, he gives examples of various forms of trace, and of the methods of assuming the defence of a position with traces adapted and profiles corresponding to the various aspects of the combat.

With regard to the practical use of field fortification Deguise distinguishes three cases:—When there is considerable time available, when there are only a few hours, and when the work has to be executed in a great hurry during an action.

In the first case the engineer officer should receive from superior authority a disposition showing the scope of the organised defence required for a position and a general trace of the same position. In such case, says Deguise, the engineer officer should solve the tactical problem, and the chief should leave to him a very large initiative; and therefore the engineer, in carrying out the reconnaissance of the ground, should indicate on the map the distribution of the troops and the defensive organisation of the position.

In the second case Deguise recognises that the problem offers great difficulty, because works which would require several hours of labour have to be constructed in a short time. He recognises that the infantry should take part in the entrenchment of the position while the engineers are employed on special works; that these fortifications should be improvised according to the solution given to the tactical problem; and that the works ought to be constructed with light tools.

In the third case he provides for the necessity of using light tools, allotting the special works to the engineers reinforced by infantry; and he affirms that the first endeavour should be to develop the simpler and more important works, so as to be ready for an attack at any moment.

EDWARD T. THACKERAY.

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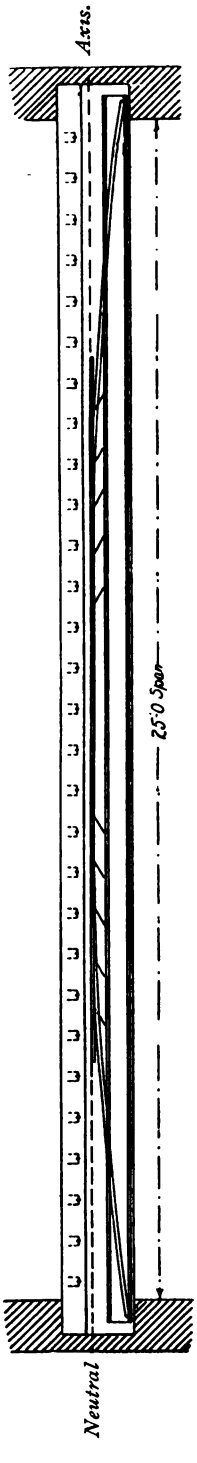

FIG. 1.—*Longitudinal Section of Beam.*

THE BUILDER.

16th February, 1907.

THE LESSON OF A CONCRETE-STEEL FLOOR FAILURE.—This is a most useful leading article on the collapse of a floor built for a small public institution in England. The failure was due to the disjointed character of the reinforcement, to the unsuitable section of two of the bars, and to other bars being placed where their strength could not be properly utilized.

The floor, 25 ft. × 36 ft., consisted of two main beams, with a clear span of 25 ft., and a floor slab; and was intended to support a uniformly distributed load of about 75 lbs. per sq. ft., some brick partitions extending to the ceiling, and its own weight.

Each beam was 17 in. wide and 12 in. deep, making with the 6-in. floor a total depth of 12 in. The reinforcement consisted of two 6″ × 3″ rolled steel joists; between them one 1½″ Indented bar, curved upwards to a height in the centre of 11 in. above the bottom of the beam; and above them, extending 7 ft. 6 in. on either side of the centre, and 1 in. below the upper surface of the beam, two 1½″ × ½″ Kahn bars with their wings downwards. The ends of the beam were built into the brick walls.

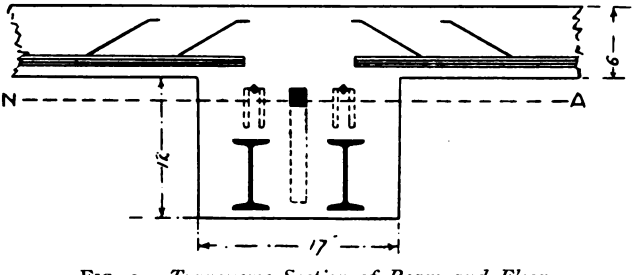

FIG. 2.—*Transverse Section of Beam and Floor.*

The reinforcement of the floor consisted of 1½″ × ½″ Kahn bars at 10-in. intervals, running in one direction only; instead of being laid continuous over the beams, these bars had gaps between their ends above the centres of the beams.

When the centring was removed, after what was supposed to be a sufficient lapse of time for the concrete to set, the floor failed under its own

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weight and that of the brick partitions. The failure occurred near the end of one of the beams. The author assumes that the designer of the floor was unfamiliar with the principles of beams and of ferro-concrete construction, or that he possessed just enough knowledge to make his knowledge dangerous.

The arrangement of the reinforcement in the beams is at variance with the principle that between the ends of such a beam and the points of contrary flexure, the upper fibres are in tension and the lower in compression, whilst in the middle length of the beam the conditions are reversed. In the case under reference the concrete in tension got no reinforcement from the bars because they were placed where the concrete was in compression. Possibly the bars were so placed to comply with a misunderstood diagram of bending moments and the steel joists were inserted because they fitted conveniently into the space available.

The author suggests that the reinforcement used might have been better applied by running the Indented and Kahn bars of the beams continuously and horizontally near the upper surface of the floor, *i.e.* simply shifting their position upwards, and by making the transverse Kahn bars continuous over the beams, leaving the joists as they were. A still better reinforcement would have been to replace the joists by two rows of three round bars near the bottom surface of the beam, and the longitudinal Indented and Kahn bars by one row of three round bars near the upper surface of the floor, providing all these bars with stirrups to resist shear. But even then the floor would not have possessed a sufficient factor of safety. It should preferably have been divided into twelve, instead of three, panels, with two 8 in. × 13 in. main beams, three 4 in. × 7 in. secondary beams, and a 4-in. slab; sections showing suitable reinforcement for such a floor are given in the article and deserve study.

A concrete floor, properly designed, and constructed so as to ensure the monolithic connection of the concrete throughout, becomes one slab stiffened by ribs. The slab constitutes a compression flange for all the beams and the secondary beams act as stiffeners to the main ones. The design involves careful analysis of stresses, correct determination of the proportions of every part, and reliable calculations for the percentage and disposition of the reinforcement.

Unqualified persons should not dabble in construction on rule-of-thumb methods, but should obtain the assistance of an expert. Ferro-concrete beams and floors cannot be designed by the aid of catalogues; rolled steel joists are usually out of place in such work, and patented bars possess no magic qualities that can compensate for the lack of knowledge and experience.

A. T. MOORE.

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CORRESPONDENCE.

THE BATTLE OF HASTINGS.

SIR,

Some further notes on this great decisive Battle of the world may be of interest to R.E. officers.

In studying simultaneously the documentary evidence relating to the general details of some comparatively ancient battles whilst engaged in following out the course of events on the actual battlefield, it is astonishing how difficult it is sometimes to reconcile many of the recorded facts with the traditional descriptions generally or locally given, although these latter may occasionally cast valuable sidelights helping us to clear up ambiguous or doubtful points under discussion.

In the case of the Battle of Hastings for instance, as revised by Major-General James, late R.E., in the January number of the *R.E. Journal*, dealing amongst other controversial questions with the correct site of the "Malfosse," it appears that there has been in the past some old tradition, on which the idea has been based that there were remains of ancient British earthworks at this spot. These might, if existing at the present time, help us in fixing this important site.

In Mr. C. W. Oman's work, *The Art of War in the Middle Ages*, published in 1898, a speculation is made that traces of ancient earthworks existed on the battleground, but other authorities (Freeman, Round, Hon. F. Baring, Sir James Ramsay, and Major-General James, late R.E.) have not judged that there was sufficient evidence in support of this idea. The extract from William of Jumièges "Nam crescentes herbae antiquum aggerem tegebant" may have originated the tradition as to these ancient earthworks; and this evidence, it is considered, must only be accepted for what it is considered to be worth. The 'Fosse Disaster' in reality appears to be rather too obscure a matter to be easily settled.

Major-General James regards the "Malfosse," in the position assigned to it in the plan accompanying his article, as a mere ravine hidden by brushwood, into which the pursuing cavalry stumbled in the darkness; but the Bayeux Stitchwork pictures an obstruction which appears to have a decided similitude, in the eyes of some authorities, to a mount Fort (with Fosse and Bailey).

To the minds of others, the Tapestry represents an artificial rampart with an unexpectedly-met-with herbage-covered Fosse on one side, such as in fact would be some prehistoric hill Fort, so nearly obliterated that its rampart, still visible to the Normans, did not suggest the existence of the ditch which proved to be their deathtrap.

The inscription on the Tapestry "Here fell together English and

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French in battle" is supposed by Lancelot and Sharon Turner to indicate that particular event in the battle, when, deceived by a feigned retreat of the Normans, the Saxons were thrown into disorder, and the Normans themselves, coming suddenly upon a great ditch concealed by vegetation, and afterwards called "Malfosse," perished in great numbers, dragging the Saxons also into the said Fosse.

In the account of the actual battle written by William of Poitiers—which is considered by the authorities to be the best description of the fight—no mention is made of the "antiquum aggerem" referred to by William of Jumièges, nor of the palisade and fosse touched upon by Wace.

If an "antiquum aggerem" of somewhat similar character to that at Bigbury Camp near Canterbury—which is referred to by Cæsar as an old fortification said to have been used in former times in some civil tribal war—really existed in 1066 at Hastings, it should be sought for somewhere about the main battle ridge taken up by Harold.

The earthworks at Bigbury, corresponding to the traditional "antiquum aggerem" of Hastings, are mentioned in Cæsar as having formed in the year B.C. 55 a "point d'appuie" or rallying "place d'armes" for the main resistance of the Belgae-Cantianae defenders, soon however to be rushed by a Roman Phalanx issuing out from behind the cover of a traverse hastily thrown up by their Legionaries.

It seems unlikely that at Hastings Harold carefully selected his battle position relying on the existence of an "antiquum aggerem," which may have been visible in 1066, but that he chose rather to fight thereon because of the splendid defensive position ready to hand, and owing to the force of circumstances which led him to assume the defensive on William's unexpectedly sudden advance to meet him.

William of Normandy on the other hand, hoping, it is said, to pounce upon Harold in the open and defeat him by his superior tactically trained troops, is reported to have been unpleasantly surprised on finding Harold resorting to prepared position tactics. As the site of the "Malfosse" adjudged to be the true one by Major-General James, Hon. F. Baring, and Sir Augustus Webster had not been accepted by Sir James Ramsay (in the *Foundations of England*), who preferred a spot much nearer the Standard, it would, owing to the persistency of the tradition theory as to the "antiquum aggerem," appear to be well worth the while of an enthusiastic expert to endeavour to trace the foundation of the idea to its source, and to pursue the search on the ground itself.

But after the lapse of nearly 8½ centuries, and owing to the changes due to cultivation, houses, terraces, and trees, it is a little more than doubtful whether the topographical details on the old-time terrain of Senlac could now be recognised by any of those of the actual combatants who so bravely fought to a finish round the Saxon Standard.

The discrepancy between the numbers of the troops engaged on the Norman side as recorded by the documentary evidence and those calculated by computations based on the carrying capacity of the invaders' sea-transport is a striking one. 60,000 Normans are mentioned by William of Poitiers, but it would appear that about 11,000, as estimated by Major-General James, conveyed across the Channel in 700 ships and boats, is

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likely to be nearer the mark; for it must be remembered that the accommodation provided by the largest of the ships is for 25 men only, being based on the information conveyed by the pictorial data of the Bayeux Tapestry and other corroborative evidence.

This conclusion is partially supported by the evidence of an ordinance of Henry III., dated 1229, prescribing the contribution in warships and crews to be provided by the Cinque Ports as a nucleus for a British Navy.

Dover had to send 21 ships, Winchelsea 10, Hastings 6, Sandwich 5, Hythe 5, Romney 5, Rye 5, thus making a total of 57; each vessel to carry 21 men and 1 boy. These warships were to be provided at the cost of the Cinque Ports for a training of 15 days yearly, many special privileges by way of compensation being granted to the several ports.

In this connection it is to be noted that at the Conquest one exceptionally large ship existed, the Dreadnought of the times,—that of Remigius—which was only of sufficient interior capacity to accommodate 20 knights, their bâtmen, and their horses.

Thus the 57 ships provided in 1229 by the Cinque Ports were equivalent nearly in carrying capacity to 57 Dreadnoughts at the time of the Conquest.

Again, as regards the Saxon numbers, one of the Norman writers has recorded a total of 100,000. The popularly accepted numbers figure up to 25,000. Wace states that the opposing forces were about numerically equal. Major-General James, R.E., makes out a strong case for some 11,000 strong.

As the old Constitutional Force at the time, including all those male adults of suitable age who were capable of bearing arms, is given by Hume as numbering 48,770, or one-twentieth of the total Anglo-Saxon population, their duties comprising the preservation of game, the repairs of roads and bridges, as well as Militia duties, the effectives of the only line available to fight the two successive battles of Fulford and Stamford Bridge on the 20th and 25th of September respectively would probably not exceed a maximum of 20,000.

When the losses suffered in the defeat at Fulford and the large defections reported as having taken place after Stamford Bridge are considered, and afterwards the rapid march concentration movements in order to arrive off Hastings by forced marches on the 13th of October, the total effectives in the striking force at Harold's disposal may, it is considered, be largely discounted.

This reduction is to a certain extent borne out by the narrative of the old chronicler Florence of Worcester, who states that at York on the 1st of October Harold was still deficient of half his troops who were not yet assembled, but nevertheless did not hesitate to meet the enemy in Sussex without loss of time.

Yours faithfully,

O. E. RUCK.

The Editor, "R.E. Journal."

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RECENT PUBLICATIONS.

Ce qu'il faut retenir de la Guerre Russo-Japonaise, par Lieut.-Colonel Picard. (8vo. 3.50 frs. Chapelot, Paris).

Zehn Monate Kriegskorrespondent beim Heere Kuropatkins. Persönliche. Erlebnisse und kritische Betrachtungen aus dem Russisch-Japanischen Kriege, von Oskar V. Schwartz. (5 mks. Schröder, Berlin).

Meine Erlebnisse während des Feldzuges gegen die Hereros und Witbois nach meinem Tagebuch, von Oberleut. Helmuth Auer v. Herrenkirchen. (2 mks. Eisenschmidt, Berlin).

Artillery Fire: The Battery, by Major W. A. Nicholson, R.F.A. ($7\frac{1}{2} \times 5$. 5s. Stanford).

Wiederholungsbuch der Befestigungslehre und des Festungskriege, von Haupt. v. Toepfer, Adjt. der 4 Ingenieur-inspektion. (3 mks. Eisenschmidt, Berlin).

Der Kampf um Sperrbefestigungen. Nachtrag zum Grundriss des Festungskrieges, von Haupt. W. Stavenhagen. (75 pfs. Gupel, Sondershausen).

Die Feldbefestigung. Nachtrag zur dritten Auflage vom Grundriss der Befestigungslehre, von Haupt. W. Stavenhagen. (90 pfs. Mittler, Berlin).

Der Festungskrieg, von Major v. Fritsch, Militärlehrer an der Kriegsakademie zu Berlin. (4.50 mks. Liebel, Berlin).

Approximate Estimates: A Pocket-Book for Estimating, by T. E. Coleman. 3rd edition revised and enlarged. ($3\frac{1}{2} \times 5$. 5s. Spon).

The Modern Plumber and Sanitary Engineer, by sixteen Specialist Contributors under the editorship of G. Lister Sutcliffe, A.R.I.B.A., M.R.S.I. Divisional Vol. I. (10×7. Gresham Publishing Company).

Experiments on Hot-Water Systems, by A. Sayers. (Sanitary Publishing Company).

Pocket-Book of Aeronautics, by Major Hermann W. L. Moedebeck, Badischen Fussartillerie Regiment, in collaboration with O. Chanute and others. Authorised translation by W. Mansergh Varley. ($5\frac{1}{2} \times 4$. 10s. 6d. Whittaker).

Houses and Gardens, by M. H. Baillie Scott. ($12 \times 8\frac{1}{2}$. 31s. 6d. Newnes).

Signs and Portents in the Far East, by Everard Cotes. ($9 \times 5\frac{1}{2}$. 7s. 6d. Methuen).

The Whirlpool of Europe. Austria-Hungary and the Habsburgs, by A.R. and Ethel Colquhoun. (9×6. 15s. Harper).

Sketches in Mafeking and East Africa, by Major-General R. S. S. Baden-Powell. ($8\frac{1}{2} \times 12\frac{1}{2}$. 21s. Smith, Elder).

The Stable Handbook, by T. F. Dale. ($6\frac{1}{2} \times 4\frac{1}{2}$. 3s. Lane).

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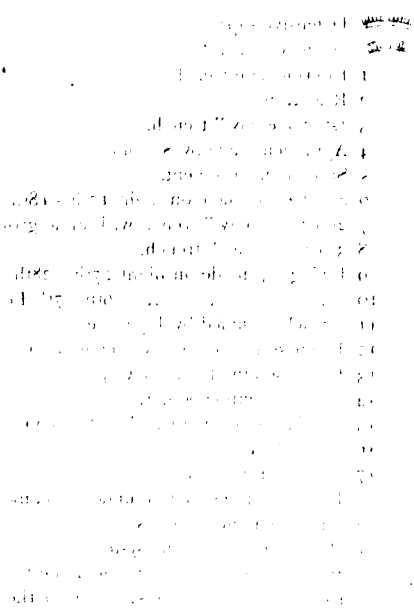

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,, W. H. Moore, D.S.O., R.G.A.
,, J. P. Mackesy, R.E.
,, B. W. B. Bowdler, R.E.
,, F. D. Farquhar, D.S.O., Coldstream Guards.
*Capt. R. G. Parker, Rl. Lancaster Regt.
Capt. G. N. T. Smyth-Osbourne, Devonshire Regt.
Capt. V. H. M. de la Fontaine, East Surrey Regt.
Capt. and Bt. Major F. R. Hicks, Hampshire Regt.
Capt. H. S. Williams, Dorsetshire Regt.
,, B. D. L. G. Anley, D.S.O., Essex Regt.
Capt. R. S. Hamilton-Grace, Durham Light Infantry.
*Capt. H. F. Baillie, Seaforth Highlanders.
,, P. S. Allen, Gordon Highlanders.
,, J. K. Cochrane, Leinster Regt.
,, R. L. Ricketts, Indian Army.
,, W. K. Bourne, Indian Army.
,, F. W. Lumsden, R.M.A.

The following Officers received nominations:—

Capt. H. C. Bickford, 6th Dragoon Guards.
Capt. C. J. C. Grant, Coldstream Guards.
Capt. W. D. Wright, V.C., Royal West Surrey Regt.
Capt. C. H. Harington, D.S.O., Liverpool Regt.
Capt. H. Wake, D.S.O., King's Royal Rifle Corps.
Capt. and Bt. Major N. J. G. Cameron, Cameron Highlanders.
Capt. G. P. Grant, D.S.O., Indian Army.

SANDHURST, JUNE, 1906.

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48th	H. G. Gauntlet 4,515	181st	C. W. Molony 3,445
67th	D. Macdonald 4,299	186th	P. J. I. Synnott 3,386
89th	W. G. Bagot-Chester 4,115	190th	R. M. Aylmer 3,339
90th	A. G. Ottley 4,109	197th	O. Gough 3,262
93rd	A. P. Williams-Freeman 4,094	201st	P. W. J. A. Stomm 3,151
115th	D. M. Black 3,940	213th	B. W. Molony 2,881
125th	W. J. King-King 3,846		

WOOLWICH, JUNE, 1906.

31st ... ... J. S. Barkworth 6,483

DECEMBER, 1905.

SECOND	H. G. MacGeorge 7,196	16th	R. Crofton 6,330
FOURTH	G. Walton 7,046	45th	D. Stephenson 5,899
FIFTH	H. A. Cox 6,967	54th	J. Kennedy 5,711

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A. E. Hardy	 2,304	W. F. Anderson	 1,947
N. H. Hutcheson	 2,105	D. C. Robinson	 1,879
F. D. Frost*	 1,949	F. A. Bowring	 1,876

*Read partly at the Army College, Aldershot.

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THE ROYAL ENGINEERS JOURNAL.

Vol. V. No. 5. MAY, 1907.

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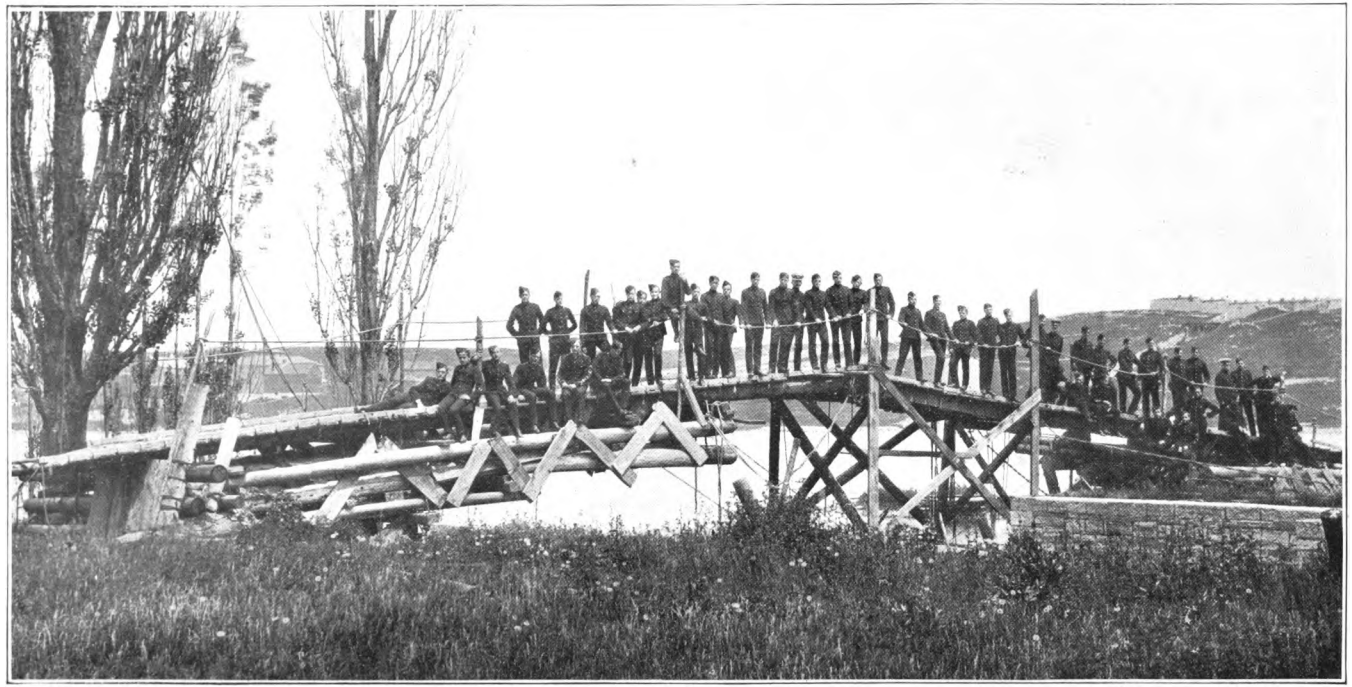
CANTILEVER BRIDGE, 80 FT. SPAN.

Constructed by Cadets at the R.M. College, Kingston, Canada.



(1). The left anchorage consisted of a tree and posts in the ground, as described in para. 3c, "Details of Construction."
(2). The bottom of the central girder (para. 5e) is hidden in the photo by the foreground.
(3). Owing to different levels of banks the highest point of the bridge is to the left of the central girder.

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CANTILEVER BRIDGES.

A COMPARISON WITH OTHER SINGLE-SPAN TYPES, WITH NOTES ON CONSTRUCTION AND CALCULATION.

By CAPT. E. N. MOZLEY, R.E.

ENGINEERS who study economy of construction in time and material know well that bridge spans should be as short as possible down to a certain limit; in other words, wherever two points have to be connected with a bridge it is generally advisable to have many intermediate points of support. This applies especially to military engineering, where the materials and means of erection are of a somewhat improvised kind, and are usually unsuitable to any ambitious designs.

COMPARISON OF CANTILEVER BRIDGES WITH OTHER SINGLE-SPAN TYPES.

Let us take a brief survey of the types of military bridges; there are six of these, viz. :—

(1). Frame.
(2). Suspension.
(3). Girder.
(4). Trestle.
(5). Floating.
(6). Cantilever.

For the reasons we have stated the Trestle and Floating types supply a large majority of the bridges actually built both in war and peace. The other bridges, being single-span, may be looked upon as necessary evils, and, interesting as they are to construct, military engineers should beware of spending overmuch time on their practice to the exclusion of the more usual kinds.

But single-span bridges have not infrequently to be built, and therefore the respective merits of the four general types of these bridges should be studied and compared.

To take the Frame Bridge first. These ingenious devices have for a very long time occupied an honoured place in our text-books and the writer therefore feels a certain reluctance in attempting to dethrone them. Iconoclasm, however, has its use in the world if Frame Bridges.

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progress is to be made; and at the risk of meeting with considerable dissent the objections to the "engineer's substitute for an arch" will be arrayed.

The example most usually quoted of the use of lock bridges is in the case of a broken arch of a viaduct. Very few engineer officers at present serving can have had experience of this case, although instances are quoted in Douglas's *Military Bridges* as having been met with in the Peninsula.

The difficulties of such a work must be great. The arch will have been destroyed by explosives, resulting in an irregular section with probably extremely friable faces. The footings will very likely have to be at different levels, even on the same side, and the probability of an irregular lock will be much enhanced. Moreover, as will be

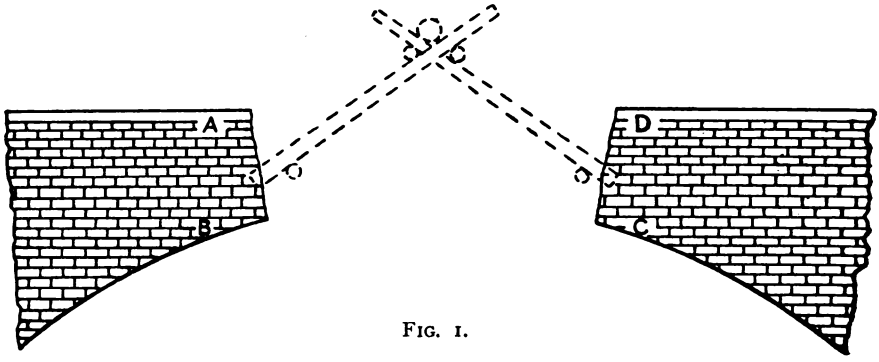

FIG. 1.

seen in *Fig.* 1 (the parapet wall being omitted), unless the depth from A to B is considerable compared with the span BC, the lock will be high above the level of the roadway AD. This will involve a ramp up in the case of single and double-lock bridges; and even in the case of sling bridges the transoms supported on the frame legs are likely to be inconveniently high.

But the chief objection to this form of construction is the probable difficulty and time involved in cutting out the footings. If the broken section AB is nearly vertical, the bricklayers or masons may well be dangling in front of the broken faces for hours, while the rest of the army looks on.

It will be remembered that the great bridge over the Tagus at Alcantara, where the gap was of this kind, was spanned by a ramp suspension bridge. The span was 100 feet, and this method could therefore be used wherever frame bridges are possible. Probably, however, for any ordinary broken arch either long beams (scarfed if necessary) laid across small gaps, or a cantilever bridge for longer spans, would be the quickest and by far the simplest method. If, however, a cantilever bridge were built in such a position it would be

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necessary to place the shore transom far enough back from the edge of the gap to prevent any possibility of the great pressure on that transom breaking down the arch again.

Under what other circumstances would lock bridges be used? Scarcely any that can be imagined. Small gaps with vertical sides occur rarely in nature. The sides will probably slope, and rarely at a steeper angle than 45°. Nor will they run together in the form of a **V**, but the bottom will probably be horizontal for a fair proportion of the span. The depth, therefore, below shore transom level will rarely exceed 15 feet for a 45 feet span. In such cases a trestle bridge will almost always be preferable to a single or double-lock. No very rapid stream is likely to run through such a gap, and the other obstacle to trestle bridges, viz., mud, can be overcome with ease.

The case against lock bridges has been considered. It rests mainly on the contention that, for all gaps except broken arches, trestle bridges could be and would be used; and that in the case of broken arches the difficulty of the footings for the frames will probably be so great that a simple span of road-bearers or a cantilever bridge would be quicker and easier to build.

The case against sling bridges rests on three points. Firstly the excessive time taken to construct them, secondly the necessity of careful workmanship, and thirdly the exceptional length of spars necessary compared with the span.

As regards time. The text-book, which employs workmen whose skill is the admiration of every practical student of the art of bridging, requires

160 man-hours to construct a 50-ft. frame bridge.
240 „ „ „ „ 60 „ „ „
336 „ „ „ „ 70 „ „ „

Each 10 feet extra span therefore adds apparently 50% to the time.

The writer has constructed with Cadet labour an 80-ft. cantilever bridge in 625 man-hours. With Sapper labour this could be reduced by one-third, to 417 man-hours. Will a Field Company R.E. put up a treble sling bridge over an 80-ft. gap of ordinary difficulty in this time? No doubt, if the eyes of the Corps were on them, they would achieve as abnormal results as did the Spectator Experimental Company when every illustrated paper contained its portrait. But we can scarcely hope for such results on an ordinary fieldworks course. Moreover we must allow for the fact that these bridges not infrequently refuse to lock. The risk is undoubted, and accuracy of measurement and careful workmanship are accordingly essential. These are the very qualities which might almost be termed unimportant in cantilever bridges.

Length of spars too is a serious drawback. 50-ft. logs, 13½ inches at the centre if unselected, are needed for a 70-ft. span. A cantilever

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bridge of the same length, with a 20-ft. central gap and the anchorages 10 ft. back from the shore, could be constructed with 37-ft. spars, which need not be especially stout if enough of them are to be had. It is true no doubt that cantilever bridges require a great many logs; but where four such big logs as those required for the treble sling bridge are obtainable, it is pretty certain that a great many smaller ones could also be procured.

Suspension Bridges.

Such are the reasons for considering frame bridges as of small practical use. No engineer would make such an accusation against Suspension Bridges. These alone supply to the military engineer the means of spanning big gaps. The civil engineer, who has at his disposal every resource of machinery, with which the field engineer has scarcely any acquaintance, can utilize steel. He can erect girder and arch bridges of no mean span and cantilever bridges which continue to hold the world's record. *Our* only means of employing steel, however, is in the form of chains and cables, though with what excellent results has been shown in Chitral and Gilgit.

While however it is acknowledged that for long spans suspension bridges have neither an equal nor a second, yet for smaller types, between 50 ft. and 120 ft., they not only take rather longer time than might be expected but are also distinctly unsteady. It is only when the weight of a bridge is large compared with that of the usual traffic that this unsteadiness begins to disappear.

Suspension bridges moreover require cables (or else time and wire to make them) and also careful workmanship. Their principal rôle is undoubtedly to span big gaps.

Girder Bridges.

The question of Girder Bridges has scarcely received from the Corps the attention it deserves. These bridges have one great merit, which no other, save perhaps floating bridges when swung out, can claim; they can be constructed in secrecy and then launched with great speed. This quality alone should give them a place in every text-book. They are also very stiff. Their chief disadvantage is the necessity of careful construction.

As regards time the following information will be of use:—An 80-ft. girder bridge (both girders being braced together before launching) was built by Cadet labour in 296 man-hours. It was launched under circumstances of exceptional difficulty,* which could scarcely have occurred on service, in 400 man-hours, and the bracing and roadway completed in 90 man-hours. On ordinary occasions the time required for launching could easily be halved, and such a bridge could be completed from start to finish in 600 man-hours of Cadet labour, which is about equivalent to 400 man-hours of Sapper labour. The actual work done under the eyes of a possible enemy, viz., the

* The whole girder had to be lifted lengthways over an old cantilever anchorage, protruding 2′ 6″ above ground, which it was not desirable to remove.

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launching and completion of the roadway, would probably not take more than 3 hours, if Sappers were employed: this point might of course be of vital importance.

It is not proposed to discuss further in this article the suitability of girder bridges. Their details and the arrangements for launching call for a professional paper. The conclusion arrived at by the writer is that, except where secrecy is of great importance, the type would rarely be chosen, but that for secrecy they are unequalled.*

Having briefly surveyed the characteristics of its rivals we will consider those of the Cantilever Bridge. This type is pre-eminent in certain respects. Nor can it be said to have any decided disadvantages for the spans for which it is adapted. Cantilever Bridges.

The great merit of cantilever bridges is their simplicity. They are simple in material, simple in construction, simple in adjustment. If the necessary timber is to hand they can be built quickly; and their strength need never be called in question. In no other bridge is it so easy to insure against failure. It is but a question of adding more logs, or more wire to the anchorage, or of digging the anchor trench deeper. In cantilever bridges the strength depends scarcely at all on workmanship. In trestle and suspension bridges it depends on it very greatly, in frame and girder bridges absolutely.

The chief disadvantage urged against the cantilever bridge is its shakiness in long spans. This defect is very evident if the bridge is built in its simplest form. But if a little extra material in the shape of nails and wire can be got, it is easy to make cantilever bridges practically as stiff as those of frame or girder construction for equal spans. These means will be investigated later.

To sum up. Of the four main requirements for a military bridge, viz.,

Strength (including stiffness),
Speed of construction,
Simplicity—(i.) of material, (ii.) of workmanship,
Secrecy,

the cantilever excels the other three single-span types in all but secrecy; in secrecy the girder is pre-eminent. It is probable therefore that the cantilever bridge is generally the best for spans between 40 ft. and 120 ft., unless secrecy is essential. For longer spans than 120 ft., no other type except the suspension is available for military engineers.

* A girder bridge might be the only possible one for a single span, if the only material available consisted of the small scantlings of a builder's yard.

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CONSTRUCTION OF CANTILEVER BRIDGES.

DETAILS OF CONSTRUCTION.

1. *Centre Line.*

Accurate longitudinal alignment of the layers of cantilevers is important, and will give trouble if not attended to. Lay out the centre line of the bridge with marks clear of all construction, *i.e.* beyond the anchorages on each side, and refer to them constantly.

2. *Levels.*

(*a*). In long cantilever bridges several layers of stout logs are necessary. These give considerable depth to the bridge at the abutments. It is necessary, therefore, either to excavate deep seatings for the cantilevers at the abutments, if the roadway level is to be kept flush with the ground; or to keep all the cantilever logs above ground on shore, and build up an earth or trestle ramp to the bridge at each end. The latter method is generally preferable as it takes less time and can be carried on concurrently with the construction of the bridge.

(*b*). A steep camber is desirable for four reasons :—

(i.). The usual one, *i.e.* to check traffic coming on to the bridge and facilitate its landing on the far side.

(ii.). Because cantilevers dip a good deal at their ends under a load.

(iii.). Because shore transoms are liable to sink unless the ground at the abutments is hard; and if the shore transom sinks a little the centre of the bridge will drop a good deal.*

(iv.). In order to reduce vertical oscillation in the centre. This is explained below under the heading of "Stiffness."

(*c*.). No great accuracy of levels is required, as any discrepancy can always be adjusted by adding extra transoms or blocks between the layers. Treble transoms, made up of two logs side by side with one above them, have been used on occasions between the layers of logs.

(*d*). While the anchorages are being prepared and the logs brought up, parties should be employed in scarping the ground between the anchorages and the shore transoms to the proper slope, to give camber to the lowest layer of logs.

* A cantilever footbridge of 60 ft. span was built by the writer with the shore transoms on marshy banks. After two years this bridge was found to have sunk till it resembled a ramp suspension bridge. Its camber was restored by bestriding the centre of the bridge with a pair of sheers, raising it with heavy tackle, and packing up under the shore transom. With a deep gap this of course would not be practicable.

A crib platform should be built under the shore transom, if the ground is soft.

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3. *Methods of Anchoring the Shore Ends of the Cantilevers.*

There are three ways of doing this :—

(*a*). As practised on the Indian frontier, *i.e.* by piling earth or stones on the shore ends as a counterweight. This method is rather primitive, as is indeed to be expected since no tools nor manufactured materials are used. Boards may be laid or nailed across the tops of each layer to give additional area for the material to bear upon.

(*b*). By excavating an anchor trench vertically below the shore ends of the cantilevers, and anchoring them down with wire to a sunken log at the bottom of the trench, which is afterwards filled in. This as a rule is the best way. The following points in connection with it call for notice :—

(i.). Make the bottom of the trench horizontal for a sufficient length and width, so that the anchor log may lie on the bottom and the whole depth of the trench be utilized.

(ii.). The holding-down ties may be from four to six in number, built up on the 'Aylmer' system* with composite wires. They should be made long enough to be secured with a round turn to the crosspiece above the shore ends of the *top* layer of cantilevers. But since in this case they cannot be made fast till all the cantilevers are in position, it is necessary to have in addition light 'construction ties,' made fast from the anchor log to a crosspiece below the shore ends of the lowest layer. Each crosspiece at the shore end, when placed, can then be secured by a few turns of wire to the crosspiece below it. The whole will thus be held down securely during construction, and the possibility of a slight rise of the shore ends and the consequent necessity for a readjustment of levels will be averted. When the top layer of cantilevers has been placed, the main anchor ties can be fastened to a crosspiece above them and tightly windlassed up.

(iii.). In filling in the anchor trench keep all the ties clear of earth and quite straight, or they will straighten later when the stress comes on them and the shore ends of the cantilevers will rise.

(*c*). The third method of anchoring down the shore ends is chiefly suitable for soft ground. It is as follows :—

Drive a series of piles into the ground on a line at right angles to the axis of the bridge, where the shore ends of the cantilevers will be.

* See "Notes on Bridging in Gilgit," by Major F. J. Aylmer, v.c., R.E., in the *R.E. Professional Papers*, Vol. XX., 1894.

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Secure horizontal crosspieces to these piles, and let the shore ends of each layer of cantilevers rest underneath a crosspiece as in *Fig. 2.*

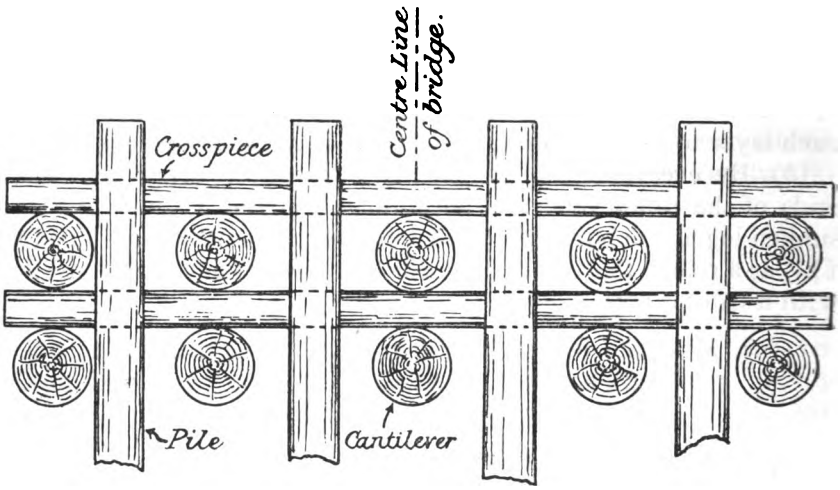

FIG. 2.

End view of bridge at anchorage.

The crosspieces may be fixed to the piles by halving or shouldering and spiking the crosspiece to the pile with dogs (which must be placed as nearly vertical as possible) or with wire lashings well frapped or windlassed up with nails.*

If there is a convenient tree on the site some of the piles on that side may be dispensed with. In such cases the crosspieces must be stout as they are subjected to a considerable upward cross-breaking stress.

An additional precaution to strengthen the connection between the crosspiece and the pile or tree is to spike a stout cleat above the former to the upright.

4. *Strength.*

(*a*). Avoid cedar or other poor woods for cantilevers.

(*b*). Paradoxical as it may seem it is generally correct to place the butts of the cantilevers outwards. The reason is that this usually gives a greater cross section where the maximum bending moment comes on the cantilever. The extra stress brought on the parts of the bridge by shifting the centres of gravity of the cantilever logs outwards is small compared to the increase of strength thus gained.

* The best way to tighten a wire lashing is with 6-in. wire nails, which are used to twist the returns of the square lashing at each corner where they pass from one log to the other. Frapping turns may be dispensed with if this is carefully done.

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(*c*). Do not allow the cantilevers to extend more than a few inches beyond the outer crosspiece above them.

(*d*). Wedge up cantilevers where necessary at the anchorage or at the outer crosspiece on which they are supported. Also, where required, insert blocks between the cantilevers and the outer crosspieces above them. These wedges and blocks will insure crosspieces touching every cantilever and therefore that every cantilever takes a share of the weight. These wedges should be constantly examined while the bridge is in use.

(*e*). Cantilevers rest generally on two crosspieces, one at the anchorage and one at the outer end of the layer below them. Between these points there is, when the bridge is loaded, a tendency to reverse, *i.e.* upward, flexure. This may be met by inserting cross logs between these two points *above* the cantilever, thus bringing the stress on the layer above. The method of vertical diagonal bracing described below under the heading of "Stiffness" will more scientifically meet this tendency to upward flexure.

(*f*). Remember that there are three methods of adjusting the strength of a layer of cantilevers.

(i.). By adjusting the number of logs in the layer.
(ii.). „ size of the logs.
(iii.). „ overlap.

5. *Stiffness.*

The following methods have been adopted with great success in an 80-ft. bridge. The bridge when completed was as stiff under marching troops as a frame or girder bridge could be.

(*a*). Short pieces of boards were nailed in a diagonal position, but as nearly as possible in a vertical plane, from the cantilevers of each layer to those of the layers above and below. They were not only nailed to the outer cantilevers but to those in the middle as well. It is necessary therefore to fix these boards (or braces as they practically are) while the cantilevers are being placed, as it is difficult to get at the centre cantilevers when the roadway is on. (The photograph explains this bracing).

It is suggested that these boards serve to some extent the same purpose as does the bracing of a lattice girder bridge, namely that they tend to give the bridge the strength and stiffness of a single cantilever whose depth is equal to the total depth of the combined layers.

(*b*). Any play or slackness due to the stretching of the anchor-log ties can be removed by wedging up tightly underneath the lowest crosspiece above the anchor trench in order to keep these ties stretched. Such play is occasionally met with in small cantilever bridges, where the weight of the traffic is considerable compared to the weight of the bridge.

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(*c*). The top layer of cantilevers, on which the roadway runs, is normally unsupported for a very considerable length. A large amount of direct and reverse flexure will therefore be experienced as the load crosses the bridge, unless this layer is

(i.). Supported by the layer below by means of crosspieces wedged between the two layers.

and (ii.). Held down by wire ties at intervals to prevent reverse flexure and oscillation when the central girder is loaded.

(*d*). The outer ends of the top layer of cantilevers on one side of the bridge may be connected to those on the other side with boards or logs securely fastened to them ; by this means a most noticeable decrease of vertical oscillation is obtained. For this reason it is important to give a somewhat excessive camber to a cantilever bridge (the ramp may be as much as 1 in 12). It will then have some of the properties of an arch, and the timbers connecting the outer ends of the opposite top layers will act with greater effect in restraining oscillation, somewhat as does a keystone.

These connecting boards may easily form part of the central girder of the bridge, and will then rest on the crosspieces underneath the outer ends of the top cantilevers, in addition to being nailed to the latter.

(*e*). A truss under the central girder as in *Fig.* 3 has been tried. It should theoretically assist in preventing oscillation, but to what extent it does so is uncertain.

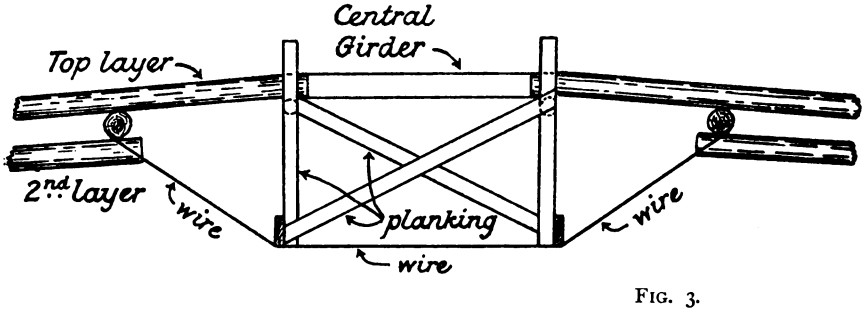

FIG. 3.

Of the methods described it was found that (*a*), (*d*), and (*c*) appeared to be most effective in the order named.

6. *The Central Girder.*

Roadbearers alone may be used to connect the opposite sides of the bridge at the centre ; but it is better, if materials are available, to build up a couple of small braced girders of 20 ft. or 25 ft. span. These girders will not only decrease vertical oscillation by being

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firmly secured to the cantilevers at each end, but will also somewhat diminish horizontal sway by the use of horizontal cross-bracing.

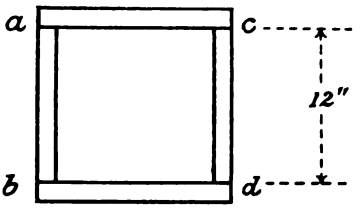

FIG. 4.

The girders may be of the section shown in *Fig.* 4, where *ab* and *cd* are two vertical planks connected at intervals by transverse vertical stiffeners and also by horizontal diagonal bracing above and below as *ac* and *bd* (see also *Fig.* 5). Composite planks may be used if necessary. The two girders themselves should be connected together with horizontal diagonal bracing.

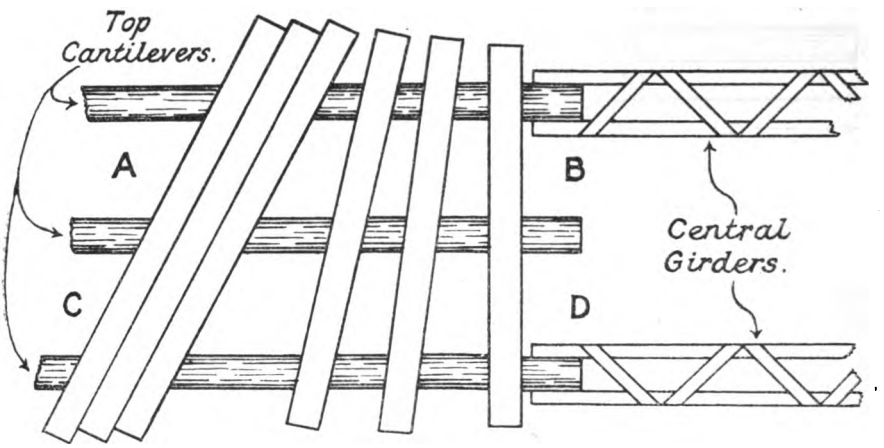

FIG. 5.

The girders, which play the double part of roadbearers and preventers of oscillation, should rest on the crosspiece underneath the outer ends of the cantilevers and be nailed to the adzed sides of the latter.

7. *Roadway.*

If the roadway is laid directly on the top cantilevers these must not be further apart than 2 ft. 6 in. centre to centre. They must be adzed smooth to get a level bearing for the chesses. The butts must also be adzed to get an even slope without a step on to the central girder.

If the roadway is a six-foot one and long planks are used diagonally, there will be difficulty where the camber changes, *i.e.* where the

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cantilevers meet the central girder. Perhaps the best way of arranging the chesses in this case is as in *Fig.* 5. Another layer of planks must be laid in the direction AB and CD to cover the spaces.

If the chesses are fastened down to the cantilevers without ribands, use wire, for wheeled traffic will cut cordage.

CALCULATIONS.

Very little is said in the text-books on the subject of calculations for cantilever bridges. The investigation necessary to ascertain the stresses is given below.

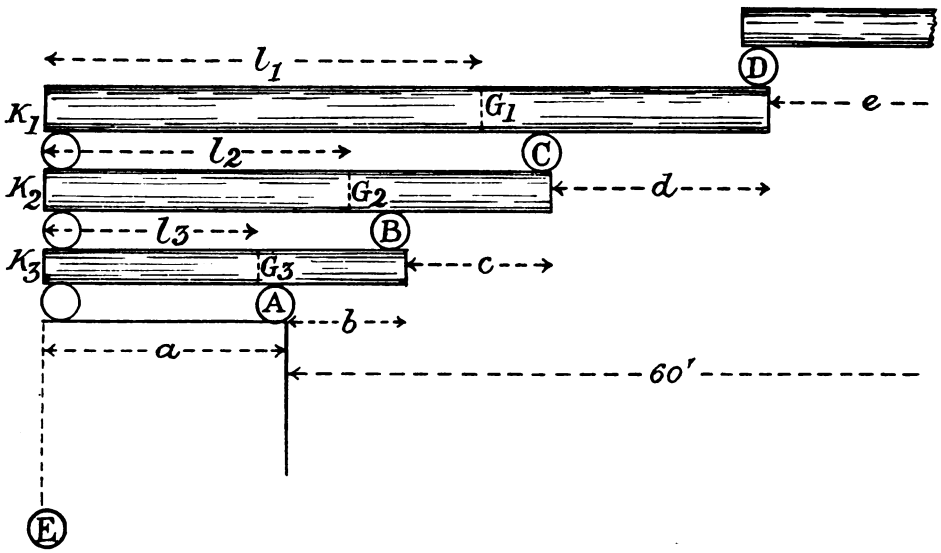

FIG. 6.

Elevation of one half of bridge.

$a = 10$ feet. $b = 5$ feet. $c = 6$ feet. $d = 9$ feet. $e = 20$ feet.
$l_1 = 18$ feet. $l_2 = 13$ feet. $l_3 = 9$ feet.

W = total weight (dead) of central girder = 1540 lbs.
W_1 = ,, top row of cantilevers = 3072 ,,
W_2 = ,, second ,, ,, = 2070 ,,
W_3 = ,, bottom ,, ,, = 2040 ,,
w = max. dead load per foot run which bridge is intended to carry = $\frac{3}{4} \times 560 + 50 = 830$ lbs.

Fig. 6 shows half a bridge, span 60 ft., in which

a is the horizontal distance between the anchorage E and shore transom A.

b, c, and d are the respective overlaps of the 3 layers of cantilevers shown.

e is the span of the central girder.

l_1, l_2, l_3 are the horizontal distances from the anchorage to the centres of gravity of the 3 layers, assumed at $\frac{2}{3}$ from the butts (butts out).

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Let the bridge be to carry infantry in fours. Assume the timber used to be spruce, and the weight of roadway 50 lbs. per ft. run (if the chesses rest on the top layer of cantilevers).

Weights.

The weights of the various parts of the bridge are first estimated as follows :—

Central Girder.—This will not exceed the weight of simple roadbearers required to carry the load across this span. By the usual formula five $8\frac{3}{4}$-in. circular roadbearers are found to be sufficient. The weight of these (22 ft. long) will be 1,540 lbs. (W).

Top Layer of Cantilevers.—There are assumed to be 4 logs, 8 in. at tip, 14 in. at butt, full length 32 ft. Their total weight will be 3,072 lbs. (W_1).

Second Layer.—There are assumed to be 6 logs, 6 in. at tip, 12 in. at butt, length 23 ft. Their total weight will be 2,070 lbs. (W_2).

Bottom Layer.—There are assumed to be 10 logs, 6 in. at tip, 10 in. at butt, length 17 ft. Their total weight will be 2,040 lbs. (W_3).

With the butts out the centres of gravity (G_1, G_2, G_3) of the layers will be respectively 18 ft., 13 ft., and 9 ft. horizontally from the anchorage.

Let w = weight of traffic and superstructure per ft. run, reduced to dead load, $= \frac{3}{2} \times 560 + 50 = 890$ lbs.

Investigation of Stresses.

Central Girder.—This is assumed to be strong enough to transfer its loads to the tips of the top layers of cantilevers.

Top Layer of Cantilevers.—The forces acting are :—

$\frac{W}{2} + w\frac{e}{2}$ at D,

$w(a+b+c+d)$, at a point distant $\frac{a+b+c+d}{2}$ from K_1

W_1 at G_1

R_1 at K_1 (stress on anchorage, assumed to be of a lifting nature on the anchorage and causing a downward pull on the shore ends of the cantilevers).

F_1 at C (pressure on tips of layer below).

Resolving vertically,

$$\left(\frac{W}{2} + w\frac{e}{2}\right) + w(a+b+c+d) + W_1 + R_1 = F_1 \ldots\ldots\ldots\ldots\text{(i.)}$$

Taking moments about K_1,

$$\left(\frac{W}{2} + w\frac{e}{2}\right)(a+b+c+d) + w\frac{(a+b+c+d)^2}{2} + W_1 l_1 = F_1(a+b+c) \ldots \text{(ii.)}$$

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Substituting values in both equations,

(i.) becomes

$$770 + 8{,}900 + 26{,}700 + 3{,}072 + R_1 = F_1, \text{ or } F_1 = R_1 + 39{,}442$$

(ii.) becomes

$$290{,}100 + 400{,}500 + 55{,}296 = F_1, \text{ or } F_1 = 35{,}519$$

Hence $R_1 = -3{,}923$ lbs., *i.e.* the shore ends of the top layer of cantilevers exert a downward pressure of this amount.

Second Layer of Cantilevers.—The forces acting are :—

F_1 at C; R_2 at K_2; W_2 at G_2; F_2 at B.

Resolving vertically,

$$F_1 + W_2 + R_2 = F_2 \quad \text{.....(iii.)}$$

Taking moments about K_2,

$$F_1 (a + b + c) + W_2 l_2 = F_2 (a + b) \quad \text{.....(iv.)}$$

Substituting values,

(iii.) becomes $35{,}519 + 2{,}070 + R_2 = F_2$, whence $F_2 = R_2 + 37{,}589$

(iv.) becomes $745{,}896 + 26{,}910 = F_2 \times 15$, whence $F_2 = 51{,}520$.

$R_2 = 13{,}931$ lbs.

Bottom Layer of Cantilevers.—The forces acting are :—

F_2 at B; W_3 at G_3; R_3 at K_3; F_3 at A.

Resolving vertically,

$$F_2 + W_3 + R_3 = F_3 \quad \text{.....(v.)}$$

Taking moments about K_3,

$$F_2 (a + b) + W_3 l_3 = F_3 \times a \quad \text{.....(vi.)}$$

Substituting values,

(v.) becomes $51{,}520 + 2{,}040 + R_3 = F_3$, whence $F_3 = R_3 + 53{,}560$

(vi.) becomes $772{,}806 + 18{,}360 = F_3 \times 10$, whence $F_3 = 79{,}117$.

$R_3 = 25{,}557$ lbs.

Therefore total upward pull on anchor log

$$= R_1 + R_2 + R_3 = -3{,}923 + 13{,}931 + 25{,}557 = 35{,}565 \text{ lbs.},$$

and the necessary depth of anchorage for a log 12 ft. long and 12 in. diameter in ordinary soil is found in the usual way to be 4 ft. 6 in. (at centre of log), using a factor of safety of 3.

If there is no live load on the portion of the bridge vertically above the horizontal length *a* (*Fig* 6), *i.e.* between anchorage and shore transom, then the stress on the anchorage will be increased to 40,219 lbs.

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To find the number (n) of cantilevers required in each layer.

Take a factor of safety=4, and the modulus of rupture for spruce $=f_0=8{,}680$.*

Bottom Layer.—The diameter of the logs at A is about 9 in.

$M_{ff}=F_2\times b=51{,}520\times 60$ inch-pounds.

$$M_r=n\times f_0\times\frac{I}{y_0}{}^*=n\times f_0\times\frac{\pi r^3}{4}{}^*=n\times 8{,}680\times\tfrac{9}{4}\tfrac{1}{4}=620{,}620\ n.$$

Equating M_{ff} and M_r and introducing the factor of safety,

$$51{,}520\times 60\times 4=620{,}620\ n,$$

whence $$n=20 \text{ nearly.}$$

Our original estimate was for 10 logs. It will not be necessary to re-calculate, as the weight of the layer bears but a small proportion to the weight it carries. Another log may be added to the layer to cover the inaccuracy, making 21.

Second Layer.—The diameter of the logs at B is about 10 in.

$M_{ff}=F_1\times c=35{,}519\times 72$ inch-pounds.

$$M_r=n\times f_0\times\frac{\pi r^3}{4}=n\times 8{,}680\times\tfrac{22}{7}\times\tfrac{125}{4}=852{,}500\ n.$$

Equating as before,

$$35{,}519\times 72\times 4=852{,}500\ n, \text{ whence } n=12.$$

The original estimate was 6. The same remarks apply as before.

Top Layer.—The diameter of the logs at C is 12 in.

$$M_{ff}=\left(\frac{W}{2}+w\,\frac{e}{2}\right)d+wd\,\frac{d}{2}=1{,}044{,}360+432{,}540 \text{ inch-pounds.}$$

$$M_r=n\times f_0\times\frac{\pi r^3}{4}=n\times 8{,}680\times\tfrac{22}{7}\times\tfrac{216}{4}=1{,}473{,}120\ n.$$

Equating as before,

$$1{,}476{,}900\times 4=1{,}473{,}120\ n, \text{ whence } n=4,$$

as originally estimated.

Pressure on Shore Transom.

This is F_3, *i.e.* 79,117 lbs. For a shore transom 20 ft. long × 12 in. in diameter the pressure will be $\frac{79{,}117}{20}=3{,}956$ lbs. per sq. ft. (The great stress here should be noticed).

The number of wires in the anchor ties is calculated from the total pull on the anchor log, viz. 35,565 lbs.

* See *Instruction in Military Engineering*, Part III.

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ROAD CONSTRUCTION AND MAINTENANCE IN TROPICAL AFRICA.

By LIEUT. G. W. DENISON, R.E.

THE road engineer in Tropical Africa is confronted with three great difficulties,—the absence of skilled labour, the presence of white ants, and the very heavy cost of transport. The rules laid down by European authorities for road construction in Europe therefore do not apply to the construction of roads in these uncivilized countries, and the engineer has to learn by experience the best way of carrying out the work assigned to him.

The scarcity of funds and the heavy expense of construction, owing principally to the cost of transport, prohibit large steel or brick structures, and most of the work has to be carried out with only unskilled native labour and with the materials which can be obtained locally.

The destructive effects of white ants upon timber makes this abundant material almost useless, as there are only two kinds of timber which they will not attack. These are mahogany and "masuka"; the first is very valuable, and the other is only a small tree seldom found of a greater diameter than eight or nine inches. Practically the only materials available for use are earth and stones.

In these uncivilized and unsurveyed countries, the surveying and construction of new roads is of far greater importance than the repairing of existing ones, which can usually be done in a couple of months at the beginning of the dry season, the rest of the year being available for constructing new ones. The engineer is frequently asked to construct a road between two places, perhaps hundreds of miles apart, through an absolutely unknown and often hostile country; and is given a very short time in which to complete the work.

ROAD SURVEY.

As the existing maps of this part of Africa are very inaccurate and incomplete, the first thing to do is to make a rough survey of the country between the two places which it is proposed to connect by the new road. This is done by first sketching the native path between the two places, taking in as much of the country on each side of the path as possible, and especially noting the size and

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direction of flow of all rivers and streams crossed. The following information should also be noted :—

(*a*). The position of marshy and low ground.
(*b*). The position of the water sheds.
(*c*). The position and extent of all isolated hills and ranges of hills.
(*d*). The position of all passes in mountain ranges and the gradients of both sides of the passes.
(*e*). The nature of the soil whether dry or damp, rocky or sandy.
(*f*). The places or streams where water can be found all the year round.
(*g*). Whether the natives of the district are friendly or hostile; whether they can be employed on the construction of the road, or whether imported labour will have to be used.

On the return journey it may be necessary to sketch a new route; but in most cases it is only necessary to stop for a day or two at doubtful places and to sketch these places with greater care.

An experienced engineer will very quickly pick out the general alignment, and especially the ruling points. Most of this he can do on the first journey, and after completing the rough survey he can draw on the map the general direction of the line.

An inexperienced engineer will have to make a more careful survey before deciding upon the general alignment.

New roads are required to connect one European station or cantonment with another, and the native towns, even if large, are of very little importance. It is better, in fact, to keep the road a little distance away from a town, and then build a rest house at the side of the road at the nearest place to the town where water can be obtained. The natives of the town form a small market near the rest house, and thus prevent "carriers" and other natives using the road from going into the town itself.

The above system is largely used in British Central Africa and North Eastern Rhodesia, and to a lesser extent on the West Coast, and works very satisfactorily.

After the general alignment has been decided upon, a more careful survey of the ground is made. This is sometimes done by running trial lines with a theodolite; but as this takes considerably more time than is usually available, the line is often "pegged out" by eye, and this can be done fairly accurately after a little practice. In doubtful places two or more lines may have to be run, and the advantages of each compared before the best line can be obtained.

It is advisable that the engineer who has to construct the road should also survey it, as he will then decide how each constructional

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obstacle is to be overcome, and may find it advisable to change the alignment. There is seldom time to make accurate surveys and drawings, and the engineer must therefore keep in his own head a deal of information which would be difficult to write down or show on drawings unless they were accurate.

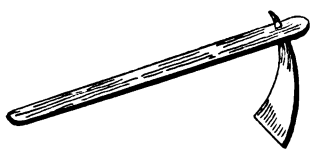
The survey and the construction is very often carried on simultaneously, the construction commencing when the survey has advanced a few miles. The engineer in charge will personally superintend the laying out of the lines, leaving a European assistant to superintend the construction; and as the survey is quicker work, the engineer can devote some of his time to the road making.

GRADIENTS.

A maximum gradient of 1 in 15 should, if possible, be kept to, but gradients of 1 in 12 are permissible if very short, such as slopes down to "drifts" or on the straight. Gradients as steep as 1 in 10 are to be found on the existing roads, but should be reduced whenever possible. On curves the gradient must be reduced and very sharp bends should be on the level.

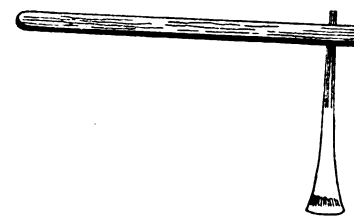
LABOUR FOR CONSTRUCTION.

The only labour available for constructing the roads comes from the natives of the country, who are only accustomed to the use of a hoe (*Fig.* 1) and an axe (*Fig.* 2). Such tools as spades, shovels, picks, etc., are of very little use in their hands; and the way they use a wheelbarrow is to carry it on their heads, so a light basket or wooden box is used for removing earth.



Native Hoe

FIG. 1.



Native Axe

FIG. 2.

The natives are organized into gangs under their own head men. The number in a gang varies from 10 to 40, but 20 is the most suitable number. Each head man is responsible for the work carried out by his gang.

Whenever possible task work, and not time work, should be used, as the natives work much harder and better when given a task.

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With task work, supervision is much easier, and more work can be got out of the men. Task work also sets up rivalry between the different gangs, and the poor workers are weeded out because a head man will discharge a lazy native and take on another in his place.

Work commences about 6.30 a.m. and continues without any interval until about 2 p.m. Each gang is dismissed by the European in charge when they have completed the task given them.

There should be an European assistant for every 500 men, and he should have a native overseer to assist him, who should be able to talk English.

The tools issued to each gang are :—

(*a*). A native hoe to each man of gang.
(*b*). 2 or 3 spades.
(*c*). 2 or 3 axes.
(*d*). One crowbar.
(*e*). One line (about 100 feet).

BLASTING.

A few of the best men are picked out and taught to drill holes for blasting; they work in pairs, each pair being provided with a drill and sledge hammer. The task for each pair is usually four holes, which takes about seven hours to complete. The number of men required on this kind of work depends upon the nature of the country, but 8 to 10 men should be trained to it.

Though the boring is done by the natives, the charge must be fixed and fired by an European, as the natives do not understand the danger of dynamite.

Dynamite is better than guncotton for blasting, as it can be rammed with a wooden rammer into any size hole, and can be fired with the ordinary commercial cap. All that is required is to break the stones in order that they can be moved. Before firing the charge it is necessary to see that the earth has been removed from around the stone; if this is not done only the portion of the stone which is above ground will be broken, and probably another blasting will have to be carried out before the whole stone is removed.

CROSS SECTION.

It is very difficult to say what is the best cross section to adopt, but the cross sections used in Europe can never be obtained. Through level dry country the cross section shown in *Fig.* 3 is the best; it is cheap and easily constructed, and the surface gets very hard from the heat of the sun during the dry season. The surface water should be conducted away from the sides of the road to lower ground whenever possible.

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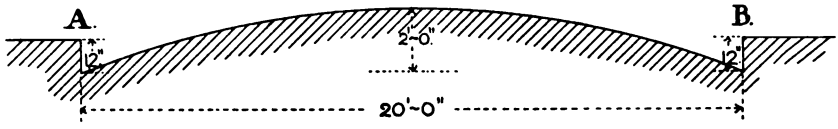
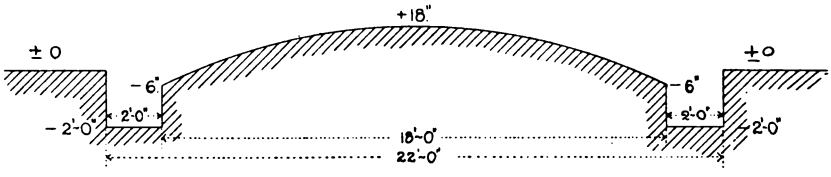


Cross Section on Level Ground.

FIG. 3.

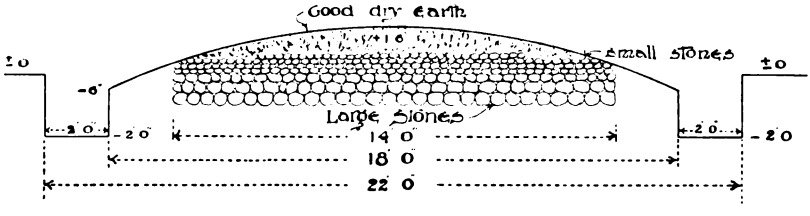
Fig. 4 shows the best cross section over a marshy place; the deep ditches collect the water and keep the surface of the road dry.



Cross Section on Marshy Ground.

FIG. 4.

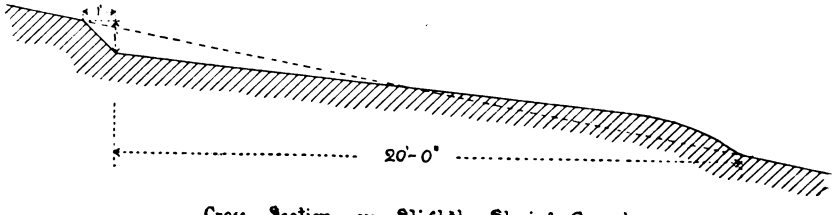
Sometimes it is necessary, if the earth is very soft, to form the road as shown in *Fig.* 5.



Cross Section on very Marshy Ground

FIG. 5.

Fig. 6 shows the cross section for slightly sloping grounds; *Fig.* 7 on the side of a steep hill; and *Fig.* 8 on a heavy gradient but with a horizontal cross section, such as the approaches to a straight "drift."



Cross Section on Slightly Sloping Ground.

FIG. 6.

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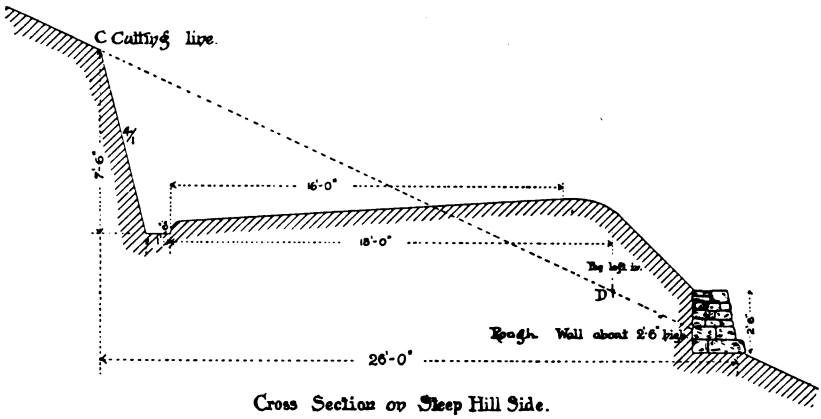
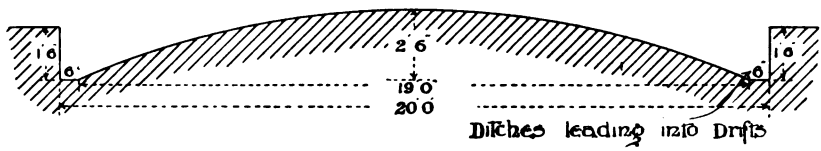


Cross Section on Steep Hill Side.

FIG. 7.



Cross Section on Approaches to Drifts

FIG. 8.

SURFACE OF ROAD.

As steam rollers are so expensive good metalled roads are never seen in Tropical Africa. The only form of metalling used is broken stone placed on the surface of the road, but of course this gets very bad during the rainy season. Most of the roads are therefore plain earth roads, the surface of which gets very hard from the heat of the sun and from the traffic of thousands of natives passing over it in their bare feet.

DRIFTS AND SMALL BRIDGES.

Streams are best crossed by means of "drifts," as wood is destroyed by white ants and iron and steel are very expensive. Drifts are made as follows :—

Several layers of stones are placed in the river bed where the road crosses it, the biggest stones being placed on the down stream side; on top of these are placed smaller stones; and on the top of all about six inches of earth. The banks of the stream are cut away and left at a gradient of 1 in 10, if the stream is crossed on the straight; if not,

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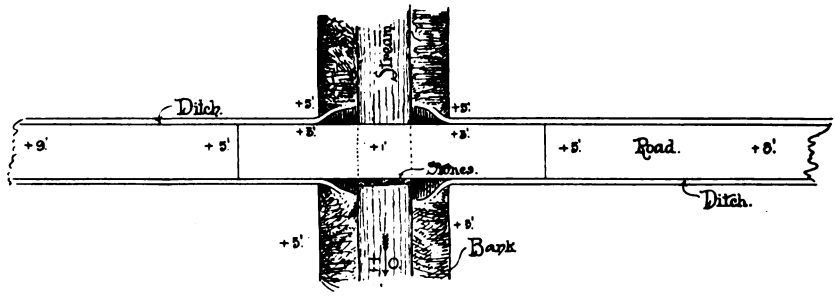
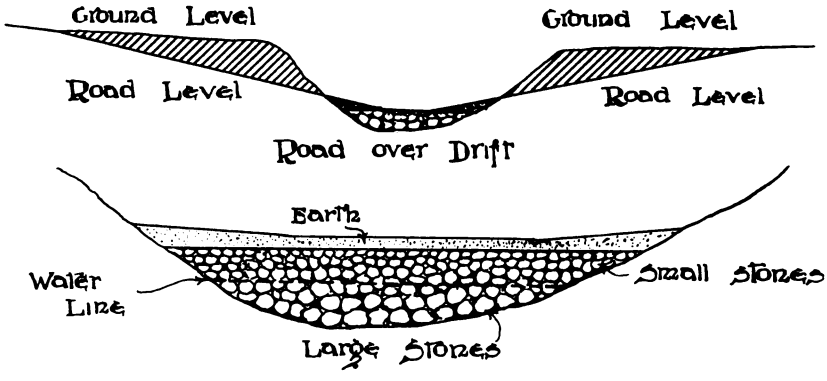
the gradient of the slopes on each side of the "drift" must be reduced (see *Figs.* 9 and 10).



Plan of Drift.

FIG. 9.



Cross Section of Drift (Enlarged)

FIG. 10.

Drifts are cheaper and last longer than small bridges; but sometimes it is necessary to build small bridges in order to save elevation or in places where it is impossible to cut away the banks on each side of the stream.

In building small bridges stone is a better material to use than bricks, as the local bricks are very soft and will not stand well when exposed to the action of running water. If timber is used to bridge the span, it must be either mahogany or "masuka" as already explained; other kinds of timber will not stand more than a few months.

CONSTRUCTION.

For constructional purposes it is advisable, when choosing the alignment, to keep on the driest ground possible, and in places it will pay to obtain this at the expense of length or elevation. If the

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alignment can be kept along a water shed, it may be long and difficult to construct, but it will be dry and the cost of maintenance will be small. Traffic is hindered less by an extra mile of good road than by a few hundred yards of bad. A good example of this is on the Blantyre-Zomba road in British Central Africa. The road purposely rises about fifty feet to the top of a small plateau, goes across the top, and then down again on the other side, thus getting on good dry level ground for about four miles, with no streams whatever to cross. To have gone round the base of the plateau would have gained a little in length and elevation, but the construction would have been very heavy, with several streams to cross; also the maintenance of this piece of road would have been very costly, whereas the four miles along the top of the plateau cost practically nothing for repairs, and the rise of fifty feet at a gradient of 1 in 15 is no obstacle to an ox team.

After the centre line has been pegged out by the survey party the two side lines are laid out before the construction party commences work. When the country is flat these two lines mark the two cutting lines of the sides of the road as shown at A and B in *Fig.* 3, and they will each be 10 feet from the centre line of pegs.

If the road is on the side of a hill, the upper line will be the cutting line, and the lower one the outside edge of the road when completed, as shown at C and D in *Fig.* 7. The line on the lower side is taken up shortly after the work commences, and only the pegs the line was fastened to are left in. In this case the upper line will be 11 to 15 feet away from the centre line, according to the steepness of the ground.

The cutting lines are laid out at least one day before work commences, and are kept at least a day in advance of the construction. This saves a good deal of time, as there is sure to be some confusion in the morning if the cutting lines are not down before the men commence work.

The tasks are set as follows:—each head man is given a certain number of yards run along the road, according to the number of natives in his gang. The number of yards per man will vary from one on very steep or hard ground to eight or ten on very easy level ground. The engineer soon learns how many yards to take off, or add on, if the work is harder, or easier, than that given to the other gangs. Thus on the same day one gang may have three yards per man, another four, and another five. For the construction of "drifts," put one or two gangs on to complete the work, but do not split up a gang.

Each gang has to complete the section of the road given to them before being dismissed for the day. All trees, stumps, and other obstacles have to be removed, also small stones. Rocks which are too large to move are left, after the earth is removed from around them for some distance below the surface of the road, and are blown

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up with dynamite afterwards, a special gang being kept for this kind of work.

The natives in British Central Africa are very good at constructing "drifts," and need very little supervision; but the natives in Northern Nigeria and other parts of West Africa do not understand this work, and it takes a long time to teach them.

No native has any eye for a straight line. Therefore never allow any work which requires to be straight, such as ditches, to be commenced unless a line has already been put down by an European.

If the surface of the road is at all damp cut away the trees on each side of the road, and the hot sun will help largely towards keeping the road good. If the ground is dry and sound, it is not advisable to cut down the trees at the sides.

As there is very little wheeled traffic footpaths are not necessary, and the usual width of the road is 20 feet on the level and 18 on embankments and hillsides. Roads of widths between 30 and 40 feet were tried in Zomba, British Central Africa; but they were very expensive and difficult to maintain, and had no advantages whatever over the narrower ones.

Avoid marshy ground as much as possible. But if it is necessary, as it often will be, to cross a marsh, get the surface of the road as dry and hard as possible. First cut deep ditches on each side, and if this is not sufficient, put in a foundation of stone as shown in *Fig.* 5. "Corduroy" roads, like those in America, cannot be used except for very temporary work.

As far as possible "drifts" should be constructed during the dry weather, for then they will have several months to settle before the heavy floods come on. If constructed during the rainy season the work is very likely to be carried away in a flood before it is completed. The above also applies to bridges; in Northern Nigeria the piers of a large railway bridge were carried away by a heavy flood before they had time to set.

As the chief form of transport is ox wagons, which take up a large length of road, sharp curves or bends are very difficult to get round. If they come on a steep incline they must be made as flat as possible and also very broad.

TRAFFIC.

The nature of the transport varies in different parts of Africa. In some parts horses will not live, while in others they can be obtained in large numbers, but they are never used by the natives for wheeled transport.

In British Central Africa, Cape carts (wagons) drawn by eight span of oxen are largely used. Each wagon carries from 2 to 2½ tons, and will cover about 15 miles in a day. They travel up and down the roads in convoys of several wagons under an European.

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Traction engines are also used, varying in weight from 7 to 16 tons, so all bridges, culverts, etc., must be constructed to take this weight.

In Lagos and Northern Nigeria horses can be obtained, but up to the present have only been used for pack purposes. Mules and donkeys are also largely used as pack animals by the natives. In Somaliland and other desert parts camels are largely used, but usually only as pack animals.

Light mule carts have been tried in different parts of Africa ; they are not as economical as the ox wagons, they do not appear to be able to stand the rough roads, and in most places have not been a success.

In all parts of Tropical Africa the native "carrier" (coolie) is largely employed, but roads are being constructed in order to avoid this form of transport as much as possible.

MAINTENANCE.

The rainfall during the wet season of the year is in most parts of Tropical Africa very heavy, and as much as 15 inches in a week is common. This heavy rain is very destructive to the surface of the roads, forming great ruts, especially when the road is on a hillside. The water also washes away the earth and leaves the road covered with loose stones, which renders it almost impassable until repaired. The drifts also suffer to a great extent and some get carried away each year.

During the rainy season the natives will not work, and consequently repairs cannot be carried out until the beginning of the dry season. It is therefore necessary to go along all the roads, as soon after the rains as possible, with large working parties, and put the roads in repair. This can be done at the rate of two or three miles a day with 500 or 600 men. In British Central Africa over 100 miles of road were repaired within a month with 3 Europeans and about 1,500 natives ; the roads then remained in good condition during the whole of the dry season. The repairing of this 100 miles cost approx. £400 or £4 per mile.

A few natives can be kept during the rainy season by paying them very high wages ; they are used for repairing drifts and removing landslides and other obstacles, thus keeping the roads open for the small traffic which uses them.

MATERIALS.

Earth is good in most parts and easily worked.

Bricks can be made locally, but are very soft and do not weather well.

Stone is fairly plentiful and easily obtained.

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Wood is very abundant, but cannot be used (except mahogany and "masuka").

Cement is very expensive indeed.

Dynamite is also very expensive, but very useful.

Steel and *Iron* are hardly ever used.

LAND.

Land has practically no value in Tropical Africa, except inside the cantonments. In most of the British Crown Colonies and Protectorates the land is entirely in the hands of the Government, and there is no difficulty in running an alignment in any required direction. In British Central Africa $\frac{1}{20}$th part of any estate may be taken by the Government for roads or railways without any compensation to the owners. Compensation must, however, be given for damage done to crops (coffee); but this is very small.

ESTIMATE OF COST.

As the chief item in the cost of roads in Africa is the labour, it may be well to state here the pay of the native in the different parts.

In West Africa the pay of a native labourer is 5/- a week; 2/- of this is paid at the end of each week, and the remaining 3/- when the native is discharged.

In British Central Africa and Rhodesia the pay is 3/- a month and 6d. a week food money; as on the West Coast, the pay is held over until the native has completed his engagement, which is usually three months.

The tools and materials required, such as dynamite, hoes, etc., will cost about £500 a year, and the pay of the European staff will be extra.

100 men working for one month cost £100 (approx.) in West Africa and only £25 in British Central Africa. In ordinary country 100 men will in one month complete about 3 miles of road. Thus in British Central Africa construction cost £10 per mile (approx.) and in Northern Nigeria and other parts of the West Coast £40 (approx.), including cost of tools and material.

In easy country it would be less and in difficult country it would be more. If any steel bridges have to be constructed the cost of them would of course have to be added to the above estimate.

The methods employed in Tropical Africa appear very primitive; but it must be remembered that the distances are long, labour unskilled, materials scarce, funds hard to get, and the time available for survey and construction often insufficient.

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*THE THIN END OF THE WEDGE.**

By Capt. L. H. Close, R.E.

In the discussion of schemes for organization for Home Defence it seems to be generally accepted that there is no *via media* between conscription and voluntary enrolment (whether in the Militia, the Volunteers, or local bodies such as rifle clubs). The best authorities recognize that the strength of our defensive cadres is inadequate to meet the possibility of an attack on us by one of the Western Continental nations, so they advocate conscription; while the opportunists content themselves by suggesting modifications directed towards the strengthening of our existing system.

In the face of the opinion of experts it is only reasonable to disregard the theories of the latter school, and to accept the view that numerically the Home Defence forces of the Crown are far below the proper standard. But at the same time, while we accept the standard of the experts as to numbers, we are not obliged to believe (as they, or the majority of them, do) that conscription or the Militia ballot presents the only solution of the problem.

The opposition to conscription lies mainly in disinclination to compulsion—in the feeling that the liberty of the Briton is being encroached upon—and to some extent also in the belief that the cost of the experiment would be as prohibitive as its effect upon trade would be disastrous.

Of these two objections, however, the argument as to cost is invalid. It arises mainly from the popular idea that conscription means that *all* able-bodied men must bear arms; whereas the number actually required to serve can be exactly adjusted to requirements by the percentage of exemptions allowed when the ballot is taken. Requirements must be met in any case, and there is no *a priori* reason for supposing that the cost of enrolment under conscription would exceed the cost under any other system.

The second objection, however,—that the liberty of the subject is being interfered with—is far more reasonable, and is wholly true to the extent that a compulsion to serve, if the recruit is unwilling, must weaken the whole fibre of the Army. To argue that the pressed men of the Napoleonic wars were excellent fighters is beside the point. At that time the condition of labour was so far less favourable than it is now that service in the Navy must have proved to many men a

* This article was written before the publication of Mr. Haldane's proposals for a reorganization of the Auxiliary Forces.—Edr.

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more desirable life in all essentials than they could ever hope to command at home. The fact remains that at the present day one volunteer is worth ten pressed men.

The preamble of this argument is now concluded, and we are left with the *residuum*—Can the State by any means compel to volunteering? Put thus bluntly the question seems paradoxical, but is not as paradoxical as it seems.

In the opinion of the writer the whole problem is capable of solution by means of compulsion on *employers* of labour, instead of on labour itself; so that the pressure, instead of being direct, becomes indirect, and there is no interference with the liberty of any particular individual. For him it will be simply a balance of advantages; whether to accept greater security for the tenure of his employment, with probably higher wages, and the possibility of having to help defend his native land; or to keep out of the defensive forces with the knowledge that, other things being equal, his value in the labour market will be always less than that of his fellow who is enrolled in some defensive corps.

Such a result as here outlined can be attained unquestionably by means of a State edict to the effect that every employer of labour must maintain at all times on his establishment a certain minimum percentage of labour enrolled in one or other of the defensive corps, under a monetary penalty for every unit of labour deficient from his proper percentage. It would not be a difficult matter to assess the pecuniary value to the State of every citizen soldier, and this value would be recoverable from every firm whose books and muster-rolls, when checked periodically by properly accredited Government officials, showed an average defect of one citizen soldier during the year, and for greater deficiencies in proportion.

What would then happen would be an effort on the part of employers to induce their employés to enlist up to the percentage laid down by the State. To achieve this end they would either offer higher wages to individual men willing to enlist, or take on new men. In either case the desired result would be attained:—The pressure exercised by the State on the employer would lead to the voluntary enrolment of as many men liable to be called out for Service as was deemed expedient by the State.

In order to adjust this scheme of recruiting to the case of small firms, shops, private establishments, etc., the Home Defence army would be organized in different corps, which would become liable for service in succession and in which the period of service would be successively reduced. Thus, if 5 corps of 150,000 men each were determined on, the period of service in the 1st Corps might be fixed at 10 years, that in the 2nd 8 years, and so on down to a service of 2 years only in the 5th Corps. But it would be only in the gravest national emergency that the 5th Corps would ever be called out; so

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that an obligation on a firm having only 2 employés to have one of them in the 5th Corps could not be considered a pressing burden. Moreover training itself would be varied in its effectiveness and duration on a descending scale corresponding to the probability of any corps being called out for service. The men of the 5th Corps might only be asked to muster at intervals, and to belong to a Rifle Club; while the men of the 1st Corps should be given the most thorough training that was financially possible.

Of course we do not need to be told that training is a matter of expense. That is so under every imaginable scheme. But, in the opinion of the author, what differentiates this scheme from all others yet propounded is its elasticity. Does the Government want to be able to lay its hand on men in large numbers who will come forward at once under arms although their training is sketchy? It can have them, and make sure of getting them at a minimum of expense and without in any way exacerbating public opinion. This is one extreme of the scale. Again, does the Government require a highly trained Home Defence Army of 150,000 men, ready to go anywhere and do anything, and to back them up by other corps whose somewhat inferior training can be improved while they are waiting to feed the First Line? This can also be done, and done as cheaply as by conscription, and with infinitely less dislocation of labour.

The highest authorities argue for a 3 months' universal training. As regards the individual this is to take place once for all; but to keep cadres up to strength it is obvious that at some centre or another there will have to be facilities for giving such training yearly. The inevitable result will be heavy expense in conveyance and housing. But if for this we substitute local corps which come up for a larger or shorter period yearly, or which simply parade or muster on stated days, all this source of expense is avoided.

Let us keep the main argument clear, however. A 3 months' training, if it is essential, is just as easily effected by means of the scheme here advocated as under conscription. But the point is, if we have 150,000 well-trained men to meet the first shock of an emergency, can we not afford to risk bringing the training of the 2nd Corps up to the three months standard after the emergency is upon us? It has to be remembered that the difference between the two corps in fighting efficiency is not represented by 3 months but probably by 1 month of training, since, on our hypothesis, the efficiency of the training increases progressively from the 5th Corps up to the 1st.

Again, is it not the modern tendency to look on the cohesion of the body as a whole as of equal importance with the training of the individual? and where is the cohesion of the battalion, regiment, or battery to come from, if the individuals who are to form them go off

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after one period of training to their own homes and only re-appear when their services are required for war?

But by means of compulsion on employers to maintain Home Defence soldiers it is known *ab initio* that the numbers of the latter will vary directly as the population of any district. Consequently within a radius of a few miles a battalion or other unit can be formed the members of which will always be found living in or about the same villages or streets, since the localities of the firms by whom they are employed do not change. Hence cohesion is at once attainable, an intimate knowledge between officers and men, and that continuity of regimental feeling which is of the highest value.

Moreover, is there not a world of difference between the security given by dependence upon the willingness of citizens to enlist in a hurry and at the last moment and the security of having absolutely in hand 750,000 men sworn to serve whenever called upon by the State? The first case spells chaos, and the delay of every detail of organization when delay is fatal; the second case eliminates every danger due to faulty organization, since what is known beforehand can be prepared for beforehand. And, since half a loaf is better than no bread, the cohesion resulting even from only an occasional muster of the unit, which can be provided for in the second case, is an immense step in advance of the entire absence of previous association between men who have to be taken from any quarter where they may offer themselves.

It is to be concluded, therefore, that, even if the training is of the slightest, the organization in war-units of bodies of men known to each other is a most important step. Having taken the numbers considered by experts to be required for all the emergencies of a war between two first-class powers, divide this total into distinct armies, and each army into local battalions or other war-units according to the proper proportions of each arm. Then decide how best to spend the money available for the training of the whole:—whether by giving the first line of defence a very high proportion of the total expenditure, while leaving the other armies more to local and voluntary effort; or by assigning allotments to each army roughly in proportion to the period of service for enlistment in each.

It may be asked—Why should anyone enlist for the long service of one of the first lines? Obviously because the State is pleased to assess his value higher when he thus serves; and the State value becomes the market value. If the relative inconvenience to the employer resulting from maintaining a man belonging to the 1st Army, for instance, is made somewhat less than in the case of his maintenance of men of the less highly trained corps, through a high value being placed on the man in the scale of equivalents in pounds sterling per annum which the firm must maintain or be fined, then a demand will arise in the labour market for men willing to enlist in the 1st Army,

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since the employer has to engage fewer of them in proportion and so will lose less over the enhanced rates he must pay for labour.

The adjustment of these different equivalents will necessarily be largely experimental, but there is no reason to suppose that the experiment would be attended by risk. There can be no doubt that 700,000 recruits would be forthcoming at once if the Government were to enact that all employers of labour must maintain ten per cent. of Home Defence soldiers on their establishments, under an average penalty per man of £100. This hypothetical average value of £100 per man might then be raised to £150 for men of the 1st Corps, and lowered to £20 for men of the 5th Corps. Thus, if a 10 per cent. levy is decided to be sufficient for the defence of the country, an employer of 100 men must maintain in his establishment the defensive equivalent of $\frac{10}{100} \times 100 = £1{,}000$: this would be given by 7 men of the 1st Corps, for $7 \times 150 = £1{,}050$. On the other hand an employer of only 2 men would be required to maintain the defensive equivalent of only $\frac{2}{10} \times 100 = £20$. This he could accordingly do by drawing one of his two employés from the 5th Corps.

It is clear that on these lines the system is easily adjustable to the conditions of every description of employment, whether in the town or country. Now, if it is decided to have a minimum training of 10 days for the 5th Corps and a maximum of 50 days for the 1st Corps (in both cases yearly), it is evidently advantageous to the employer to maintain men of the 1st Corps rather than those of the 5th; for the value of each man in the former corps is £150 to him, and the relative cost 50 days of absence from employment; that is 5×10 days, the equivalent absence of 5 men of the 5th Corps, whose maintenance would only lower his indebtedness to the State by $5 \times 20 = £100$. Thus, by increasing the value of units in the most highly trained lines of defence out of due proportion, a premium is clearly put upon their engagement by employers.

We come lastly to the question—Would such a scheme work? As to this it is only possible to say that it mitigates every irksomeness inherent to conscription; and if the latter, which is a system of direct compulsion on the individual, is feasible, a system of indirect compulsion on the employer is *a fortiori* so. Would the men enlist? Yes, because the employer makes it worth their while to do so, and those employers who fail to offer attractive terms must pay in hard cash to the State. These payments enable the State to add to its regular, *i.e.* Imperial, forces.

As to the employer we need waste no pity on him. The commercial operations by which he grows rich are only possible because there is a general feeling of confidence in the adequacy of the national defence. Directly this feeling begins to vanish rates of interest go up and trade suffers. Since national confidence is based

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upon the views of experts, as soon as these views become unfavourable it is the duty of the State to add to its defences until the requirements of the experts are met; and to do so it is clearly justifiable to tax both capital and labour, for both are profit-sharers. But labour is only taxed indirectly owing to the slight rise in the cost of living that increased national expenditure must entail.

While conscription can only be introduced against the active opposition of both Capital and Labour, recruiting by means of State compulsion on employers would only have to encounter the opposition of Capital. But capitalists are not devoid of reason; and it is probable that they would welcome a satisfactory organization for Home Defence, even if they had to pay more for it, provided it could be shown both that it is essential and that it will give an economical equivalent for the money spent.

It has to be recognized that against the introduction of this scheme many might raise the cry of State interference with private concerns. It does not seem certain, however, that there need be much more interference than now takes place under the Factory Acts. From the Government point of view all that is required to be known is the average daily strength of labour employed by a firm, averaged on the working days of 1 year. These figures for each firm would form the basis on which to compute the numbers of Home Defence soldiers that should be included within the firm's establishment for the next year.

Medical inspection of would-be recruits would be necessary, but the standard would be made less rigorous for the less highly-trained corps.

In order to keep the war units of the different armies up to strength during a war provision would have to be made for maintaining reservists for each army. Probably the simplest way of effecting such provision would be to treat certain units of one Army as depôt units for the supply of the Army next above. Thus, of the 150,000 men in the 2nd Corps 50,000 might be organized as depôt units to feed the 1st Corps during war. The independent strength of the 2nd Corps would thus be only 100,000 men, for which the 3rd Corps would maintain 30,000 reservists, its independent strength also being 100,000, and its full strength, including its reserves for the 2nd Corps, 130,000.

The scheme could be introduced gradually by raising the percentage of Home Defence soldiers to be maintained by employers of labour from an original levy of 4 per cent. by 1 per cent. increase per annum up to 10 per cent., which percentage would probably suffice to give the gross total required.

The officering of units of the different Corps would be carried out by local Boards of officers of the Regular forces appointed for the purpose by the War Office. The salary drawn by any gentleman, being the market value of his labour, would roughly indicate the

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relative rank he should hold as officer, if, in other respects, he is found to be fitted for the post. A monetary equivalent could be found for the value of an officer's services, increasing with rank ; so that any member or partner of a firm, serving as an officer, would largely reduce the statutory strength in Home Defence soldiers to be maintained by the firm.

It is probable that in working out the scheme existing Militia battalions could, by means of certain adjustments, be made to form the 1st Army here outlined, the 2nd Army being composed of existing Volunteer battalions. The 1st Army would be held liable for foreign service, and also those men of the 2nd Army who had enlisted as reservists for the 1st.

All that any firm stood to lose under this scheme would be the absence of 10 per cent. of its employés for about 5 weeks every year, plus the slight rise of wages to be offered to the same 10 per cent. to induce them to enlist. The only monetary loss that would occur is indicated by the latter loss. Now, if a set time were fixed for the annual training of each army, employers could make arrangements for bringing in temporary men to fill the places of their Home Defence soldiers while out for training. This they would do, not by obtaining men from other Corps whose training were over or not commenced, for such men are already employed *ex hypothese*, but by bringing in unskilled labour and moving up their un-enrolled artizans into higher paid billets, which they would hold so long as the enrolled men were away.

If, then, training takes place during the winter months, we have in this scheme probably a complete solution of the unemployed problem, for throughout 4 or 5 of the winter months there will always be 150,000 places that can be filled by unskilled labour. This method of finding work for the unemployed would seem to be in every way preferable to the expenditure of large sums on unproductive public works. By utilising the unemployed in this manner the State has it in its power to thoroughly perfect the training of all the soldiers it requires for internal defence.

To recapitulate the advantages offered by the scheme here put forward :—

(1). It meets the views of the highest experts both as to the number of men required for Home Defence and their training.

(2). It can be carried out without any compulsion on individuals.

(3). Its compulsion on employers is nominal, if the scale of penalties is carefully framed to meet the conditions of poor districts such as Ireland and the East End of London.

(4). It is absolutely elastic, and can be adjusted to meet the circumstances of the largest manufacturing firms and the smallest shops.

(5). It contains within itself the stimulus required for obtaining a sufficiency of officers.

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(6). It is completely adjustable to the circumstances of individuals, for room can be found in the various lines of defence for the young and the old, for athletes and those suffering from some non-incapacitating physical infirmity, for the adventurous and for the citizen who is tied down by family circumstances.

(7). It is wholly adjustable to the money that can be spent on it, and training can be carried out to any small or great extent in any one or all of the lines of defence.

(8). Where money is not forthcoming for training, organized bodies properly officered can nevertheless be formed, whose training in peace time will devolve on local effort, by means of rifle clubs, etc., maintained by private firms ; and in war time the whole body can be called upon to serve without the fatal delay that occurs when volunteers are called for. Such bodies, being the last lines of defence, could probably be given a training of some value after the incidence of a national emergency.

(9). It presents what is probably the best solution of the unemployed problem.

There remains one other point to be considered—the interests of the Imperial army and navy as affected by the scheme. In the first place there is nothing to indicate that recruiting for these forces would suffer under the scheme, since, except in the winter months, the number of places of employment remains as before. But the same principle can be applied for the benefit of these forces, viz. :—to make the employment of Regular reservists or of soldiers who have taken their discharge equivalent to the maintenance of Home Defence soldiers of the 1st Line ; and similarly as regards the navy. This incentive to the employment of old soldiers might be added as one of the advantages of the scheme. It is high time that the present disgraceful neglect by the nation of those who have served it well should be made to cease ; and in this way some compensation would be made them for inadequate pension or discharge without pension. Reservists of the Regular forces, and men who have passed out of the reserve, not being called out for training in peace time, would be more freely accepted for employment than Home Defence soldiers who have to train annually.

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COAST DEFENCE ECONOMY.

By 'FORTS.'

ONE feels impelled—with all diffidence—to make some observations in reply to the article on "Economy in Coast Defence" which recently appeared in the *R.E. Journal.*

The views expressed in that article seem in fact a good deal opposed to the tendency of modern coast defence policy, so far as it can be discerned. A proposal which claims, like other projects, to attain an enhanced degree of economy in defence, should be deserving of close examination, and surely cannot be harmed by some criticism and, as it were, audit, if it be intrinsically sound.

A study, superficial enough perhaps, of the trend of the changes which have been taking place over a long series of years in the general scheme of defence of these islands seems to disclose an increasing tendency to concentrate our garrisoned strength round a few important points, reckoning that defence against raids at intermediate places would be provided in the main by mobile troops. I believe I am correct in saying that defence schemes usually take account of the possibility of landings. At the same time it is but fair to say that raid, invasion, bombardment are not the only acts of hostility which can be conceived.

The defence of a coast line has of course an analogy to that of a frontier, in that it is necessarily fitted, so to say, to a fixed line. The fleet may be compared to mobile and independent troops or armies on land, submarine boats to mobile troops attached to the fortresses, and the defended places themselves to the fortresses, *forts d'arret*, entrenched camps and so forth along the frontier line. Continental opinion, it may be remarked, has, if anything, veered away from the idea of a continuous line of defence along the frontier.

I am not very clear about the central idea of Colonel Hickson's scheme; but from the calculations he puts forward of the number of batteries he would propose, it seems to be that the coast line should be equally strong everywhere, that is to say, in other language, that the intensity of defence against attack should be equal all along the line. One cannot help thinking of affairs in the Peninsular War—many of us have perforce had to gain some cursory acquaintance with the Peninsular. There at least it was shown that attempts to hold a long line in equal or equivalent strength were apt to fail when a

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determined enemy made an attack in strength on one point before a concentration could be brought about.

Strong everywhere! So was the Great Wall of China. But has the Great Wall availed to prevent the barbarian getting in? A system of Coast Defence which relies on walls or their equivalent alone is foredoomed to failure. To aim at being equally strong everywhere under practical conditions inevitably means not being strong anywhere: that is the essence of Napoleon's advice to Massena to "concentrate on the decisive point!"

However, the extra armament is to be spread along the intervals between the defended ports, in batteries of single guns, or twos or threes: not the same thing as having guns mounted on railway trucks so as to allow of their coming into action at any point when the railway approaches sufficiently close to the coast. As a matter of fact at most of the places where the line runs near the shore the deep water is some distance out.

It is certainly a fascinating picture to imagine the enemy's fleet coasting down the channel in search of a "soft place" to land at, and being warned off every fifteen thousand yards by a policeman in the shape of a big gun. How about the chance of these isolated batteries being silenced in detail?

The time factor cannot be neglected. To produce much effect on a defended port, unless an absolute surprise is effected, demands a certain amount of time. Consequently an enemy may be expected to go at his objective as directly as he can once the objective is decided on, lest haply he should be interrupted before anything had been accomplished.

"Inducement," one may venture to think, must be a very strong factor in formulating any scheme of attack. The bigger the prize the bigger the risk an enemy would take. It is all very well to talk of a "fortress incubus," as some writers have done. This may be a convenient phrase. But fortresses have a way of hampering an enemy's movements to a serious degree; they cannot be swallowed up as he goes along; even with the best intelligence he is not likely to be able to tell with certainty what they have within them, either in the form of men, stores, or munitions, or what they guard: and the chronic problem besetting an invader is that of keeping up supplies of all kinds. In fact for an invader in the present day once the line of communications, whether over sea or land, is secure half the war is over. A raid with a force which is not capable of holding on until other pressure is brought to bear cannot hope to accomplish much, and would simply amount to the expenditure of so many men and so much matériel and, perhaps, prestige, a thing less tangible but more expensive it may be.

We have seen often enough, or at least we know from history, how the risk of attack from a hostile force near or far off has affected the

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course of war both on land and sea. It is not necessary to search out and quote particularly apposite examples, but the case of Nelson's fleet in the Mediterranean may be remembered.

Apparently we may assume that Colonel Hickson's scheme does not contemplate any diminution of existing fortress or harbour defences, and mainly provides for additional batteries along the coast. By the way, it may not be out of place to remark that the Royal Commission of 1859, which went the round of our coasts, recommended, if I remember right, the installation of a prodigious number of guns; but on broader strategical grounds it was decided to mount new armament at only some of the places considered.

The first cost of these new batteries is estimated certainly, but how about a system to command them and to supply them? The command of a long straggling line, even in these days of improved telegraphic apparatus, is a much more difficult affair than that of a compact fortress. Land, it may be remarked in parenthesis, is exceedingly expensive, particularly where it has to be bought in small lots.

A coast battery by itself is terribly exposed to attack. It sounds paradoxical, but everyone knows that field guns cannot be risked without escort of other troops; still less can heavy guns in permanent works be left unprotected by other arms, lest an enemy should attack the work and render it untenable or kill the gunners. Apart from raids, landings, and invasions it would be folly to neglect the possibilities of treachery. Why should not aliens in this country, at the outbreak of war or even before, turn themselves into franc-tireurs and so make it easy for the official enemy?

One may venture to express the opinion that the greatest danger coast defences have to provide against is land attack—another paradox, but defence matters are seamed with paradoxes. No one has really contested the view that ships have a very poor chance of effect against modern guns mounted in modern works. The chance of getting in an effective hit is too much in favour of the battery. Is it likely then that ships will themselves attempt to silence the batteries; surely rather they will give them a wide berth unless steps have been taken first to render them innocuous?

The new additional batteries will thus involve having attached to them a considerable number of coast defence troops. I have not attempted to make an estimate of numbers, but there would have to be a pretty solid deduction made from the army remaining after the Striking Force had sailed and the fortress garrisons were provided. Presumably it would be right to estimate on that basis, although, as indicated above, the main danger to our coast defences will be at or even before the Declaration of War.

It seems hardly fair to ascribe the Martello Towers and the monumental works of the Palmerstonian era wholly to a sudden fear

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of invasion. Was not the feeling of insecurity rather due to previous neglect of defence? Of recent years at all events our defence projects have been based on some sort of scientific consideration of the probabilities of war.

After all, it is strategy which determines all the preparations: in fact I fancy Peace Strategy has been recently defined as including *all* the measures, both military, social, and political which go towards preparedness. The worst of it is that the Army, as a body, has little opportunity of being acquainted with what the other side intends to do, but for that matter politicians are not always such augurs as to be able to foretell it either. As the sea runs between us and the invader it rests with our sailor men to do the prophesying in the first instance, and with us to believe them just as much or as little as prophets are wont to be believed.

Evidently, the author of "The Economy of Coast Defence" has not been tinged Ultramarine by the Blue Water School. That is clear, but it is *so* difficult to prophesy what will or will not happen in war that we may all be allowed a little liberty to theorise.

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TRANSCRIPT.

WING TRENCHES.

Précis of an article by COLONEL S. A. TSABEL *in the September-October*, 1906, *number of the* EENZHENERNEE ZHOORNAL.

DURING the latter part of their war with the Japanese a distinct order was issued to the Russian troops by their new Commander-in-Chief, General Linovitch, directing that in the fortification of positions all redoubts, irrespective of local conditions, must be made to accommodate 2 (double) companies, and that wing trenches or "whiskers," each capable of holding 1 company, must be constructed on the flanks of each redoubt, so that in the redoubt and its wing trenches accommodation should be provided for a whole battalion. It may here be mentioned that, as far as the wing trenches are concerned, all arguments referring to redoubts apply with equal force to villages or any other local objects which may be put in a state of defence to form *points d'appui* in a fortified line.

The above-mentioned order led to frequent discussions among the Russian officers as to the efficacy and the correct form and use of these wing trenches. While obeying the order many Russian Engineers were not convinced as to their utility, and among these may be numbered the writer of this article, who is a man of wide experience, having superintended the defences of the 2nd Army at Mukden and subsequently had charge of the works on the Gunchuling and other positions.

The advocates of wing trenches may be divided into three groups. The first of these, which included General Linovitch himself, held that each redoubt and its wing trenches should be garrisoned with a full complement of 4 companies, thus bringing the fullest development of frontal fire to bear on an attacking enemy. In the later stages of the defence, however, the troops occupying the wings must be prepared to retire within the redoubt; and if, after this, the attack be repulsed, they must re-occupy the wings in time to fire on the retreating enemy.

The second group held that the intention of these trenches was two-fold,—firstly to act as a place of retirement for the garrison of the redoubt during the artillery bombardment, and secondly to provide the unoccupied portion of this garrison (*i.e.* the men told off to occupy the gorge parapet, or the interior reserve) an opportunity of making use of their fire during the earlier stages of the defence. In this case, as before, the wing trenches had to be in direct communication with the redoubt, but they were manned with troops included in the garrison of the redoubt and were not allotted a separate garrison.

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The third group considered that the trenches should be given independent garrisons, who would not be withdrawn into the redoubt at any period during its defence.

The following arguments are brought against the opinions of the first group:—

(i.). The garrison of a whole battalion is larger than can be usually spared for the defence of one *point d'appui* however important.

(ii.). If a whole battalion is allotted, surely it would be better to increase the size of the redoubt itself, rather than break the continuity of its front by making wing trenches.

(iii.). There would be considerable difficulty in transferring so many men from the wings into the redoubt and back again through narrow openings in the parapet during the later stages of the defence, and there would be danger of the enemy getting in on the heels of the defenders.

(iv.). There would be inconvenient overcrowding in the redoubt when four companies were drawn into a work intended only for two.

(v.). Would not the wing trenches form convenient lines of approach for the enemy up to the parapet of the redoubt? If special obstacles are prepared for closing the gaps caused by these trenches in the ring of obstacles surrounding the redoubt and in the parapet itself, could the men be trusted to close them thoroughly on retirement, and could they remove them equally quickly when re-occupying the trenches?

(vi.). The trenches, in order that they may not serve as cover for the enemy, must be perfectly straight, uninterrupted by traverses or blindages, and enfiladed from the flanks of the work. Under these conditions, in any but perfectly level ground, it would not be possible to get any field of fire from the trenches.

(vii.). Trenches forming part of a redoubt must remain, with the redoubt, silent until the enemy arrives within medium ranges of the work. Would not the extra troops be better posted in separate trenches, where they could bring long range fire to bear upon the advancing enemy without disclosing the position of the redoubt?

Against the use of wing trenches as cover for the garrison of the work during an artillery bombardment the following arguments are brought:—

It is doubtful if the cover obtained in these trenches is really better than that found within the redoubt. It is a mistake to consider the trench as a line and the redoubt as a space; for the redoubt is really nothing more than two lines, and, though certainly more vulnerable than a trench, it is not exceedingly so. Besides this, within the redoubt there can be made all kinds of splinter-proof cover, traverses, etc., while the trench, for fear of its giving cover to the enemy, must be made straight and without any such shelter.

From actual experience no definite decision was arrived at as to which was the safer; sometimes the wings suffered more than the redoubt and sometimes the reverse was the case. With the modern tendency towards careful masking and the difficulty in observing artillery fire there is no doubt that the wing trenches often received hits from shells which were aimed at the redoubt.

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If the garrison is removed at all during the artillery bombardment it should be withdrawn to some shelter prepared for it in a fold of the ground in rear of and to a flank of the work, the communication with which must be carefully screened from the enemy's view. But many commanders consider that the risk of delay in re-occupying the work is too great to make it advisable for the garrison to be withdrawn under any conditions.

As to utilising the wing trenches to enable men from the gorge parapet and from the reserve to take part in the earlier phases of the defence, it is urged that, as these men have distinct duties to perform within the redoubt, they should be kept entirely for these duties; otherwise when they are required they may not be in their places. If they could be spared for the additional defence of the front face this face might be increased to accommodate them, but otherwise they should be kept carefully under cover in those parts of the redoubt which are most conveniently situated for their allotted tasks.

This tendency of bringing into the firing line even those troops which should be kept back as a reserve proved fatal on a large scale at Mukden, and it is surprising how quickly that expensive lesson was forgotten. At Sipingai the 3rd Army was at first placed in reserve in rear of the other two, but it was soon brought up to extend the right flank of the main line, which line attained the enormous length of 150 versts (100 miles).

The third party advocated a redoubt with wing trenches permanently occupied, the whole surrounded by a continuous belt of obstacles. But this is only effective against an attack from the front, as the wing trenches can offer no resistance towards the flanks and themselves would mask any flank defence from the work itself. They would therefore defeat the whole object of the closed work.

Even if it were arranged that the garrisons of the wings could be withdrawn to the rear in the later stages of the attack, the obstacles on the flanks would remain at too great a distance from the work for effective defence.

It therefore appears that, in the opinion of the writer, every form of wing trench is bad. But he suggests that, if it is considered necessary to reinforce the frontal fire of the redoubt by any exterior trenches, these trenches should be placed in rear and to the flanks of the redoubt and should be manned by troops not included in the garrison of the work. In fact the 'whisker' should not be a 'whisker' at all, but an 'adjacent' or 'neighbouring' trench to the redoubt.

These adjacent trenches should lie outside the redoubt's belt of obstacles and might be surrounded by obstacles of their own. In the position suggested there would be no objection to their being provided with traverses and splinter proofs.

They should have separate communications with the rear; and, if not provided with special garrisons, might be occupied by the troops who are driven back in the intervals between redoubts.

They might possibly be connected with the shelters, mentioned above, provided for the use of the garrison of the redoubt during bombardment;

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so that, if the trenches are not otherwise occupied, the garrison could be transferred into them, moving to one side or the other to escape the concentrated searching fire of the enemy's guns.

When the writer was fortifying the Gunchuling position at the end of the war, he devised a modification of the wing trench as a means of satisfying the order for the universal application of these trenches. In this, each trench consisted of two parts—(1) an inner or wing trench proper, about 40 paces in length, lying within the obstacle belt, and (2) an outer adjacent trench for one company, roughly in continuation with the former, but separated from it by the belt of obstacles and not connected with the redoubt in any way. The inner trench was straight; but the outer one was curved in order to secure a good field of fire, and was provided with traverses and splinter proofs.

F. E. G. SKEY.

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REVIEWS.

DES PRINCIPES DE LA GUERRE.

By Colonel of Artillery F. Foch.—(8-vo., price 10frs. Berger-Levrault & Cie, Paris).

This book consists of a series of lectures to students at the French Staff College. It is impossible in a brief précis to do justice to the amount of solid food provided in these lectures, but the main points of the argument may be summarised.

As far as France was concerned there was no rational instruction in War before 1882; because our theories were false. First we had a school which ignored moral factors, whereas defeat is entirely the result of demoralisation produced by the combined and simultaneous application by the victor of moral and material factors. It sought to make War a mathematical science, ignoring the living factor—man. Then there arose another false school which taught:—"Only in War can War be learnt."

War is not a science but an art, "a terrible and passionate drama." In common with every branch of art it has a technique. This technique will not make a genius, but it is necessary even to such a man. To acquire it we must first study history in search of guiding principles. We must persevere in the study of applying these principles to cases, until from this study and experience we adopt the right course automatically and instinctively in any situation. "Il ne suffit pas de connaître les principes: il faut les appliquer, *savoir* et *pouvoir*." To this end we must always take the objective view of a situation, must always consider only "de quoi s'agit-il?"

We must then study the higher functions of war, always by the light of History.

Strategy, according to Moltke, requires the development of mind and character by means of military education and experience drawn from history or one's own life.

Genius creates: its pupils study and codify its work, and are indispensable to genius itself. For example, in 1870 the Prussian staff, unaided by genius, succeeded in manœuvring 3 or 4 armies, a task in which the unaided genius of Napoleon failed in 1812–3. We must grip truths, not accepting them as dogmas, but testing them by the sole criterion of reason, so that we may arrive on the field with a trained mind which applies principles automatically. This needs constant mental exercise. Then learn to think.

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The type of War which we study must be one suited to the immediate military policy of the Nation. For France to-day this spells "the Nation in Arms"; the type of War which was born at Valmy, and made France great during the First Republic and the First Empire. We must abandon the old 17th and 18th century schools and study these later wars, not forgetting that War is subject to the law of evolution. There is always a tendency during prolonged periods of peace to hark back to the old style, because manœuvres of necessity emphasise the material factors. We had forgotten Napoleon's teachings and got back to the old style in 1870.

The National War as opposed to the dynastic type was fought first for freedom, then for admission to the comity of nations; now it is for commercial advantages. This war requisitions the whole intellectual and material resources of the nation: demands swift decision by force: its strategy has but one aim—battle. The National War brings in its train methods suited to the national temperament and armies: it abolishes imitative but aimless strategy: it recognises that methods suitable for a long service regular are not necessarily the best for the citizen soldier fighting under the influence of patriotism.*

The only correct strategy is that which aims at a tactical advantage, as opposed to that geographical strategy which considers an advance on the enemy's communications, for instance, as an end in itself. Success is the result of superior moral and material momentum, and demands attention to three points—preparation, concentration, impulse. Motion is the law of strategy. As regards concentration we are forced in practice to form detachments at first for purposes of reconnaissance, security, etc.; and to disperse for marches. The study of the economy of Forces teaches how to reconcile practice and theory.

Carnot first taught and Napoleon practised the right system—Concentrate your efforts against the enemy's main force: seek its annihilation in a decisive battle and relentless pursuit: "contain" him elsewhere with the minimum possible force. We must have covering detachments (generically, advance guards) to ensure free play for our main force.

Thus the system becomes that of dividing our forces into:—Advance guards exploiting the quality of resistance, and a main force exploiting the quality of shock.

The lecturer illustrates these principles by a lucid and detailed study of Napoleon's advance into Piedmont, 10th to 17th April, 1796.

In the fourth lecture Colonel Foch develops the study of how to obey. There is but one man directing the strategy of a war; his subordinates seek only to carry out the chief's intentions: but the subordinate on the spot (the higher his command the more is this applicable) must decide for himself what are the best means to adopt to this end under the circumstances.

But "discipline does not mean the execution of orders as far as may appear sound . . . or possible; but the free entry into the thoughts

* Colonel Foch doubts the possibility of successful attack by English "mercenaries"; but omits to notice that the English attack does not leave behind it hordes of skulkers, as has been noticed in the case of attacks by "patriotic" soldiers.

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of the chief . . . ; the adoption of every means humanly practicable to give him satisfaction. Again discipline does not mean . . . the art of avoiding responsibility; but action in the sense of orders received, and, to that end, mental effort to discover the means; character to adopt the risks of execution . . .

Incapacity and ignorance are not extenuating circumstances; for knowledge is at the door of all who seek it."

To be in a position to execute orders (*a fortiori* to command-in-chief), it is essential to preserve liberty of action in the presence of the independent will of the enemy; "to attack without uncovering yourself, to threaten whilst parrying." This brings us to the study of the service of *sûreté*.* As an arm stretched out in the dark *feels* the way, *secures* from collision, *fastens* on a door handle: so covering detachments must:—

(1) acquire certain knowledge of the enemy's dispositions, on which alone may plans be based (vide letters of Napoleon to Prince Eugene, 1809)

(2) secure for the main body the time and space necessary for the preliminary manœuvres in execution of this plan (concentration on decisive point, deployment, etc.)

(3) *hold the enemy to the dispositions on which those plans have been based, until they can be developed.* This means piercing his covering detachments, and establishing contact with his main body; attacking it probably.

The principal *means* to this objective are long range fire: hence a preponderance, and free use, of artillery are essential.

These principles are well illustrated by a series of critical studies (descending frequently to the detail of the action of the companies) of advance and flank guard operations: including the "immobilisation" of Garibaldi's corps by von Kettler's brigade, January, 1871, and the battle of Nachod, 27th June, 1866.

The use of covering forces for strategic *sûreté* is also studied; the action of Ziethen's corps, covering the concentration of the Prussian army on 15th June, 1815, is considered in detail; the critical position of the IInd German army on the 16th August, 1870, is shown to be the result of a go-as-you-please order based on hypothesis not on *sûreté* obtained by a strategic flank guard.

Then in a critical study of Lannes' action at Saalfeld (10th October, 1806) Colonel Foch shows how this illustrates clearly all the fundamental principles of a decisive battle:—

(1) The six hours' *preparation* covered by the advance guard (3½ battalions, 9 squadrons, 2 guns), which drove in the hostile outposts and seized the *points d'appui* next the enemy on a front of 3,900 yards, whence it reconnoitred, contained, and held the enemy's main body. Screened and covered by this, the main

* This word is untranslatable in the sense given it by Colonel Foch, who at length and repeatedly explains that, as used by him, *sûreté* means the *material security* necessary for the free development of the plan of the chief, *plus* the *certain* knowledge (of the enemy's dispositions up to the moment of the decisive attack) on which alone such plan can be based.

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body (9 battalions, 10 guns) manœuvred for the decisive attack; disposing 2 battalions in support of the frontal attack, 2 as a flank guard, and 5 on a front of 1,500 yards for a main attack. The direction chosen for this main attack was against the enemy's sensitive flank, and over ground with defiladed approaches, but free from obstacles and giving room for the attack.

(2) The attack was launched with speed and suddenly, and therefore as a surprise; the whole force (flank and frontal attack in close co-operation) except two guns was engaged in it.

(3) The victorious troops were at once reassembled, and a relentless pursuit undertaken.

From this Colonel Foch develops his theory of the modern battle, which, he considers, will take the form of a long preparation, consisting of a progressive series of actions for *points d'appui*, each such action being a miniature battle in itself, and involving the application of the same principles. The execution of the decisive attack will generally be against a flank.

There is nothing, of course, in all this which is not inculcated in our own *Combined Training*. But these lectures give, as a condensed Training Manual cannot give, the reasons for the principles; and so form as it were an introductory study to *Combined Training*. Colonel Foch's views on the rôle of artillery, given in the final lecture, will be found worthy of study.

J. W. S. SEWELL.

POCKET-BOOK OF AERONAUTICS.

By MAJOR H. W. L. MOEDEBECK; *translated by* W. M. VARLEY.—($6\frac{1}{2}'' \times 4\frac{1}{2}''$. 10s. 6d. Whittaker).

It is satisfactory to find that an English edition of this excellent pocket-book has at last been issued. It is a most useful work, giving a large amount of general information about Aeronautics, and may almost be considered an elementary treatise on the subject. The sixteen chapters into which it is divided are written by well-known authorities on the points dealt with, and the Appendix contains many useful tables, revised and adapted by the translator for the use of English readers.

One very satisfactory detail is the number of references given to books, papers, etc., on Aeronautics; and on this account, if for nothing else, the pocket-book will be found most useful, as almost every well-known author is referred to and the exact title of his writings given.

Taking the chapters in order:—

Chapter I., on Gases, describes their physical properties, characteristic equations, etc. In a technological section, the gases specially useful for balloons are discussed in detail, with the method of preparing them. Some useful notes on the inflation of balloons are included in this section.

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Chapter II., Physics of the Atmosphere, is a general account of the properties of air, its pressure, temperature, general circulation, etc., and there is a brief note on weather forecasting.

Chapter III., Meteorological Observations, is chiefly devoted to the work done in manned balloons, and draws attention to the importance of having a definite system for recording the results obtained. Very little is said about the use of *ballons sondes*, kites, etc., but this subject is dealt with to a certain extent in other parts of the book.

Chapter IV., the Technique of Ballooning, is one of the best in the book, and, as far as the ordinary spherical balloon is concerned, goes into the subject most thoroughly. Formulæ useful to the designer are given, as also full details of the materials used, their strength, etc. The chapter is well illustrated, one of the most interesting diagrams being that of the Parseval-Sigsfeld kite balloon, used in the German and other armies.

Chapter V., on Kites and Parachutes, commences with a brief historical account of these machines, and then describes the details in connection with them. There are numerous diagrams showing different types of kites, such as the Lamson, Hargreaves box kites, etc., and much general useful information. The method of using kites in teams is described, and the chapter finishes with some details of parachute design.

Chapter VI., on the Theoretical Principles and Practice of Ballooning, is divided into two parts. In the first full details are given as to the lifting power, equilibrium, etc., of balloons; while in the second everything connected with the practical working of these machines, such as inflation, duties of conductors, landing, etc., is discussed. Even balloon sports are described, and rules for handicapping given.

Chapter VII., on Balloon Photography, describes in detail the style of camera, lens, etc., required, and there are useful hints as to the best method of using such apparatus.

Chapter VIII., on Photographic Surveying from Balloons, is a somewhat elaborate one, and gives a good deal of information about a very difficult subject.

Chapter IX., on Military Ballooning, describes the organization of the balloon service in the principal armies of the world, and gives a sort of brief diary of the development of military ballooning in each of them. In the section devoted to the British Army, the work done by the Balloon Sections in Egypt and S. Africa is described pretty fully, and the recent use of Cody's kites commented upon. In the French section there is a complete list of the balloons which succeeded in getting out of Paris in 1870–71, with full details as to the length of the voyages made by them. The "Lebaudy" is only briefly alluded to, as it is described more fully later on. It is interesting to find that the Japanese used kites in fortress warfare in 1869, the results as far as observation was concerned being very satisfactory.

The rest of this chapter is devoted to military applications of ballooning, and there are some notes on firing at balloons, throwing out shells from balloons in motion, etc.

Chapter X., on Animal Flight, is a brief one. Such an important subject

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cannot be adequately dealt with in four pages, and it is to be hoped that in future editions a much more detailed account of this interesting branch of Aeronautics will be given. There is a serious error on page 273. The formula, Section 3, para. 2, should read $\frac{F^{\frac{1}{2}}}{p^{\frac{1}{3}}} = \log \sigma$ (see *Le Vol des Oiseaux* by Marey, p. 82).

Chapter XI., on Artificial Flight, is divided into three parts. The first gives a brief account of the principal "Soaring Machines" up to the time of the Lilienthals; the well-known memorandum by Otto Lilienthal forms the second; while the third gives detailed information about the work of Pilcher, Chanute, the Brothers Wright, etc. The chapter is well illustrated, and the section on "Computations" gives some elementary ideas on the mathematics of Flight. The important question of the position of the "Centre of Pressure" is alluded to, and some few details of experiments on this branch of the subject are given; but future editions should contain more information, as this question is one of the first importance.

Chapter XII., on Flying Machines, is the most important in the book. It deals with the pressure of air on surfaces, and gives useful formulæ for calculating lift, etc. Hardly sufficient attention, however, is paid to the work done by Langley, whose remarkable and carefully conducted experiments do not seem to be quite appreciated. The results obtained by him do not, it is true, altogether coincide with those of von Loessel, quoted by the author, but they agree remarkably well with the work done by Duchemin and Kummer and are certainly deserving of more than a passing notice.

The chapter concludes with a brief account of the principal flying machines from Penaud to the present date, and some useful Aeronautical calculations.

Chapter XIV., on Motors, gives a great deal of valuable information; but tables giving details of fuel consumption, weight, floor space, etc., of different kinds of motors, likely to be used in aeronautical work, would be an improvement.

Chapter XV., on Air-screws, follows the conventional theory of screw propulsion. While a good deal of information is given about screws of different kinds, there are no diagrams showing the actual form of those referred to on pp. 432 and 434, and consequently it is very difficult to check the results given in the tables. An efficiency of only 34 per cent. seems to be extremely low for the flat-bladed propeller described on the latter page.

Chapter XVI. gives a list of the various Aeronautical Societies, and the fact that the Aeronautical Society of Great Britain is the oldest in the world is duly noted.

The *Appendix* contains a number of tables and other information useful to aeronauts

J. D. FULLERTON.

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NOTICES OF MAGAZINES.

Revue du Génie Militaire.

February, 1907.

The Lebaudy Balloon of 1905.—The envelope of this dirigible balloon was made of two thicknesses of cotton with a layer of indiarubber between. A coating of rubber was also given to the interior to protect the cotton from the impurities in the hydrogen gas.

The balloon was 57·75 mètres long, and its greatest diameter was 10·3 mètres. It held 2,950 cubic mètres of gas. To prevent the balloon from pitching it was given a horizontal bilge keel round the stern, constructed of cotton stretched on a frame.

On the 3rd July the balloon started on a voyage. The first day it made 95 kilomètres in 2 hours 37 minutes. It was anchored in the open for the night, head to wind. The car was weighted and rested on a central pivot. In order to guard against any change of wind, it was necessary to provide anchorages all round the balloon to which the painter might be attached, if required. A party of about fifty men were employed in looking after the balloon while it lay at anchor. On the second day the balloon made very little progress owing to strong winds and frequent bursts of sunshine, which caused the balloon to lose gas. On the 6th July the balloon reached Chalons, but before it could be securely anchored a gust of wind drove it against some trees, and wrecked the envelope.

By the 8th October the balloon had been reconstructed. Various ascents were made at Toul and the neighbouring fortifications reconnoitred. The greatest height attained was 1,370 mètres above sea level.

The Artillery Barracks at Halle.—These barracks were built in 1902 and are considered to be the best in Prussia. They cost £120,000, and provide accommodation for three batteries of artillery including officers. Nine men occupy each room. The floor space works out to 48 square feet, and the air space to 550 cubic feet, per man. The beds are arranged in two tiers. The officers' mess consists of a dining room, with a gallery for the band (which plays during dinner on guest nights), a smoking room, and a library.

Photographic Reconnaissance.—The principle advocated by the author is that a special wide-angle instrument should be used in taking the photographs from which it is intended to locate the enemy's works. It will then be possible to include on one plate at least three known points,

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situated at a considerable angular distance apart, from which the position of the camera may be accurately fixed on the map, and the bearing of a large number of works ascertained. A second photograph taken from a new position will then give a cross bearing for each point that appears on both plates, and so fix its position.

The telephotographic camera, which has only a very limited field, should be reserved for the details of the works themselves. The article will be continued.

J. E. E. CRASTER.

RIVISTA DI ARTIGLIERIA E GENIO.

February, 1907.

NOTES ON IMPROVISED FORTIFICATIONS.—By Capt. Cardona, General Staff.—Of two instructional books on fortification, namely *Instruction in Field Fortification* (which forms part of the practical instruction of the engineers) and *Instruction in Work of the Sapper for the Infantry*, it is interesting to examine the last, which represents an unique guide to the infantry for the improvised fortifications which they may occupy.

We may refer to the following points:—

(*a*). The means necessary to-day to satisfy the requirements of improvised fortifications.
(*b*). The character of the works in relation to tactics.
(*c*). General rules for the execution of the works.
(*d*). Rules for the employment of sappers' tools.
(*e*). Methods for adapting natural shelters or defences.
(*f*). Some types of entrenchments which would fulfil the required conditions, methods for tracing them, and models for their construction.
(*g*). Rules for constructing hasty entrenchments and artificial obstacles, and for masking the works.

With regard to the first point, while twelve years ago it may have been admissible that entrenchments were only necessary for the defence, to-day we must hold that such works are equally required for the attack, and that the use of sapper entrenching tools should accompany the use of the rifle whenever the ground does not offer natural shelter.

The general rules of a tactical-technical nature for instruction should teach the necessity of the simplest works, hastily constructed, adapted to the ground, indiscernible from a distance, and always in accordance with the tactical idea.

The rules for instruction in the use of sappers' tools should tend to make known the best way of adapting them for the more difficult conditions of service—under fire from the enemy—so as to obtain the greatest advantage with the least expenditure of labour and with the least danger.

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With regard to the adapting of natural shelter—improperly called obstacles in the instructional treatises—it is thought that precedence should be given to such adaptation of the ground (when possible) over works of shelter artificially constructed.

The types of trenches described in the instructional books are generally proscribed for the following reasons:—

1. The defender cannot fire conveniently. The internal slope of the parapet should be about 2/1 to allow the firer to rest conveniently against the parapet.
2. The parapet is too high for concealment from the enemy's view. It should not be more than $\frac{4}{5}$ths of a mètre—as in the recent Boer and Japanese wars—because a greater height renders it too visible from a distance.
3. The depth of the trench for a man standing should be about $\frac{4}{5}$ of a mètre.
4. The excavation of earth is usually excessive on account of the excessive size of the parapets and width of the trenches. For ordinary earth a height of about 1 mètre should be sufficient, and the width of the excavation at the foot of the trench should not be greater than 1 to 1·2 mètres.

The types adopted for the trenches should be few and simple, and the soldiers should have clear and practical ideas as to their construction with the least possible fatigue, and for adapting them to the various circumstances of time and of the ground. It may be noted that during the last war the Japanese made use of two kinds of shelter:—one type, for 1 or 2 men lying down, consisted of a simple isolated heap of earth, height 25 to 45 cm., sheltering the head and shoulders, the earth being taken from one or two little lateral trenches; the other type, for a firing line on foot, was a simple trench about $\frac{4}{5}$ths of a mètre deep, width at bottom $\frac{1}{2}$ mètre, with a parapet about $\frac{2}{5}$ths m.

With regard to the necessity of masking the works several measures may be adopted:—

Prevent the tracing or relief showing on the horizon;

Assimilate the appearance of the work with that of the surrounding ground, covering the parapets with clods, branches, leaves, etc., of the same colour as that of the ground;

Keep in front of the works rows of trees, hedges, cultivation, etc.;

Make use of concealed trenches in front of the masked works, at a distance of 100 to 200 m.

As to the progress and direction of the work, the rules should be framed with great simplicity, and should leave to the commander of the troops great latitude.

The following order of precedence may be allotted to works:—

1st, those that tend to increase the efficacy of our own fire,
2nd, those that are of value in protecting from the enemy's fire,
3rd, those that tend to facilitate our own advance,
4th, those that tend to offer obstacles to the advance of the enemy.

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With regard to the employment of sappers it would be convenient that the commanders of the large units should consult and take the opinions of the commanders of the engineers, allotting to the sappers the works of a less simple character—demolitions, communications, etc.—for which works the engineer officers should, where possible, be in agreement with the commanders of the detachments of infantry directly interested. It may sometimes happen that detachments of engineers may be required to be employed on works depending upon the plans of the officers commanding the infantry troops, such as the strengthening of a position, etc., and it is not impossible that disagreements should occur between the engineer and infantry officers. It should not be difficult to prevent such disagreements, if it were left to the infantry officers to determine *where* and *when* to execute any work and to the engineer officers to settle *how* such work should be constructed. If, notwithstanding this definition, disagreement should arise between the tactical commander and the technical director regarding the progress and execution of the work, whatever may be the difference in rank between the two officers, the dispute should be referred to the superior officer in command of the operations whose duty would be to decide on the question.

To the end that the drill and training of the troops in constructing improvised fortifications should be as perfect as possible it is indispensable that they should have frequent opportunities for exercise and for becoming familiar with these duties.

EDWARD T. THACKERAY.

VOËNNYI SBÓRNIK.

August, 1906.

DESTRUCTION OF JAPANESE SEA MINES AT PORT ARTHUR. — Operations commenced immediately after the loss of the *Petropavlovsk* (13th April, 1904) and continued until September or October. The greatest depth of any battleship in Port Arthur did not exceed 30 feet.

The chief method employed was "sweeping." Ten weights (lead or cast iron) were fastened, at a depth of from 42 to 49 feet, by steel ropes to 10 small casks, which were spaced 70 feet apart and connected by a steel hawser. The two casks at the ends held 13½ gallons (5 vedros) while the remainder were only 8·1-gallon (3 vedros) ones. The two outside weights were 144 lbs. (4 poods), and the inner ones 72 lbs. (2 poods). From the end weights two tow-ropes, 350 feet long, were led to two steam cutters, which steamed ahead at a distance apart of 700 feet, thus sweeping the water. When the trawl struck the anchoring cable of the mine, the mine exploded.

Frequently, however, the mine was not exploded, the trawl breaking the anchoring cable of the mine, and causing it to rise to the surface. The mine was then destroyed by gun-fire from the 37-mm. (about 1½ inches) Hotchkiss guns on the steam cutters. Sometimes however the

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trawl slipped over the mine, and to prevent this four-fluked grapnels were fastened to the trawl rope.

Destroying mines by gun-fire was rather expensive, so in many cases they were towed to the shore and then destroyed by rifle fire. The bullet easily pierced the shell of the mine and set fire to the melinite, which commenced burning, emitting large volumes of black smoke, and finally exploded. This system prevented damage being caused to the trawl, and there was not an unlimited supply of rope in Port Arthur. Some mines blew up on touching the shore, so that great caution was required in dealing with them.

In view of the shortage of explosives many of the mines were emptied instead of being blown up. This was a task demanding much precision and coolness, and was always carried out by an officer, the rank and file being posted in as safe a place as possible. The danger was due to the ends of the trawl, being washed about by the surf and waves, striking the mine and sometimes causing the vibrator to close the circuit. In approaching the mine, therefore, it was necessary to choose a moment when the waves were receding from it. The first thing to do was to screw up the mechanism. While tightening up the spring, you had at the same time to turn the endless screw, thus separating the shackle from the splitted piece, by which means the conductor was disconnected and the mine rendered harmless. You could then take off the upper lid, and, cutting the lead, proceed to empty the mine. The anchoring cable of the mine was used for mending the trawl, which required constant repairing as every explosion of a mine through its agency damaged a quarter and even half of it.

At first only two pairs of steam cutters were employed in trawling, but eventually, as the number of mines increased, a whole fleet of trawlers, consisting of eight dredgers, long-boats, cutters, and rowing sloops was utilised. For protecting this fleet a gunboat and 2 or 3 torpedo-boats used to be sent out into the roads.

Two sorts of trawls were employed, in order to clear respectively the deeper and the shoal waters. The system was the same in both cases, the weights and sizes for the heavier being as above described; the dragging was done by dredgers, drawing 7 to 8 feet, and steam pinnaces. The lighter trawls were only 350 ft. wide, the weights at the extremities being 72 lbs. and in between 36 lbs. In taking the trawls out of the water, on completion of the work, it was necessary to exercise great care, as mines sometimes got entangled in the trawl and on knocking against the sides of the tugs were liable to explode. This actually happened in one case, and a dredger was sunk, being with great difficulty dragged just in time out of the fair way.

It was impossible of course to sweep the whole of the roads, and so only a strip 6 miles long and 470 yards wide approximately was cleared. The enemy was bluffed as much as possible regarding the position of this strip, by sending out the trawling parties in various directions, some of which did not actually do any work.

Trawling near the shore was rendered necessary occasionally owing to some of the Japanese mines breaking loose. This was rendered very

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difficult, as the trawls used to interfere with the observation mines laid by the submariners, who consequently did not regard the work of the sister service with a very friendly eye.

Counter-mines were tried, but proved a failure. Mines loaded with 180 lbs., 360, and finally 540 lbs. of pyroxiline were used, but gave no result to speak of. At a distance of from 50 to 100 feet from the site of the explosion, the trawl discovered at a depth of from 14 to 28 feet unharmed Japanese mines.

The work of trawling for mines was intensely exhausting, and the strain on the nerves much more tiring than that imposed on the men manning the defences or on the ships.

C. G. FULLER.

February, 1907.

NOTES ON THE ARTILLERY DEFENCE OF PORT ARTHUR.*—The writer of this article considers that too little attention has hitherto been paid to technical matters in connection with the siege, and, himself an artillery officer, proceeds to give the results of his observations.

On the sea front there were 22 batteries situated to the right and left of the harbour. Of these only 9 were really effective, namely: four batteries of 6″ Kanet guns (Nos. 2, 9, 16, and 22), one 10″ battery (No. 15), two 9″ batteries (Nos. 5 and 17), and two batteries of 6″ guns of 63 cwt. (Nos. 11 and 18).

No. 1 Battery was intended for 57-mm. coast defence guns, for firing on torpedo-boats and landing places, but actually contained two 47-mm. guns.

No. 2 contained five 6″ Kanet guns.

No. 3, two 57-mm. guns, two others having been removed for the defence of the land front.

No. 4, eight 9″ howitzers and one 57-mm. gun for ranging. Four howitzers were removed during the siege for the defence of the land front.

No. 5, four 9″ guns of 1867 pattern.

No. 6, eight 9″ howitzers.

No. 7, four 11″ howitzers.

No. 8's two screw guns were removed during the siege for the defence of the land front.

No. 9 contained five 6″ Kanet guns.

No. 10, called "Artillery Battery," contained six 6″ guns of 63 cwt. and two 57-mm. coast defence guns for ranging. One 6″ gun was removed during the siege and mounted near the lighthouse for firing on landing places; another 6″ and the two 57-mm. guns were removed for the defence of the land front; towards the end of the siege only 2 guns were left.

No. 11 contained two 6″ guns of 63 cwt. and two 120-mm. naval guns; it was called "Lighthouse Battery." The naval guns were served by sailors.

Between No. 10 and No. 11 Batteries two 2-screw guns had been

* Compare the account from the *Organ der Militärwissenschaftlichen Vereine* in the November, 1906, number of this Journal.—EDR.

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placed near a projector, but they were removed at the beginning of the close investment.

No. 12 Battery was situated on the left side of the entrance to the harbour; it consisted of eight 57-mm. coast defence guns for firing on landing places. The guns were all removed at the beginning of the close investment for the defence of the land front.

No. 13, known as "Golden Hill," contained six 11" howitzers.

No. 14 had four 57-mm. coast defence guns for firing on landing places. All the guns were removed for the defence of the land front at the beginning of the close investment.

No. 15, called "Electric Crag," contained five 10" guns and two 57-mm. coast defence guns for ranging.

No. 16, "Camp Battery," contained five 6" Kanet guns.

No. 17, "Two-Horned Battery," contained eight 9" guns.

No. 18, "Flat Battery," had six 6" guns of 63 cwt. and two 57-mm. coast defence guns for ranging. In type it was similar to No. 10. By the end of the siege all its guns had been removed.

No. 19 contained no guns. It was built with its front facing the entrance to the harbour and almost at right angles to the fronts of all the other batteries; this was with the idea of its opposing torpedo boats and even larger craft endeavouring to force the entrance to the harbour.

No. 20, contained six 9" howitzers and two field guns of 1877 pattern. Later on all the howitzers were removed and a 24-cm. gun mounted instead.

No. 21 was armed with six 9" howitzers and two 57-mm. coast defence guns for ranging.

No. 22 had five 6" Kanet guns. This battery was constructed during the war and formed the extreme left flank of the defences.

As regards construction Nos. 2, 9, and 16 Batteries had concrete foundations, traverses, and magazines covered with earth. No. 13 was similar in construction, but without the earth covering and the concrete was thicker. No. 15 was of concrete with thick arches to the casemates. Numbers 19 and 21 were also of concrete. These are all the details given.

The only guns of any actual value for defence purposes were the Kanet guns, the 10" guns, and the 6" guns of 63 cwt.

The total nominal armament was therefore :—

10" guns...	5
9" guns	12
6" Kanet guns	20
6" guns of 63 cwt.	14
57-mm. (2·2") guns (for ranging)	8
57-mm. (2·2") guns (for use against landings)	12
Field guns	6
24-cm. (9·4") guns	1
12-cm. (4·7") guns	2
	79*

* The author appears to have made a mistake of 1 in his addition.—A. H. B.

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Total guns:—heavy	... ...	18
medium	.. ..	35
light	... ...	26
		79
Add 11″ howitzers	... .	10
9″ howitzers	... ...	23
		33
Grand total armament	... ...	112 pieces.

After the first few engagements the respective effectiveness of these various weapons became apparent.

The howitzers were the first to prove useless. They had been mounted on the highest points, so that fire could be brought to bear on the decks of vessels and the inner roadstead rendered inaccessible. But owing to the mobility of the enemy's vessels, fire from the howitzers was quite ineffectual.

As regards the 26 light guns, these were used on the three occasions when the Japanese attempted to block the fairway. An examination of the vessels sunk revealed the very slight destructive power of these weapons; consequently they were considered useless for coast defence purposes, except in case of attempted landings.

Leaving the 33 howitzers and 26 light guns out of account, only 53 medium and heavy guns remain, and of these the 9″ and the 6″ of 63 cwt. proved to be too slow in firing and also not sufficiently powerful as regards range to be effective.

Hence the 10″ and the 6″ Kanet guns, 25 in all, formed the total effective armament available, about equal to that of any Japanese ironclad. It proved sufficient, however, to keep the hostile ships at a respectful distance from Port Arthur, even after the distruction of the Russian fleet on November 27th. From January 27th to December 19th the Japanese fleet did not make a single attempt to crush the batteries.

The 10″ battery (No. 15) fired on January 27th and made some successful practice; but as a rule this battery was not often used, as the larger vessels never came within range, and the smaller craft and torpedo boats were not worth the expenditure of 10″ shells. When the close investment began the 10″ guns fired across the town at the siege batteries.

Most of the work fell to the lot of the batteries of 6″ Kanet guns (Nos. 2, 9, 16, and 22). They fired indifferently on the sea and on the siege batteries. They were nearly identical as regards field of view, equipment, and trace.

An account is given of the work done by No. 2 Battery, as being typical of the work done by the others. It was situated on the extreme right. When the Japanese fleet appeared on January 27th it was found to contain no ammunition except twelve practice shell filled with sand, so ammunition had to be brought from No. 9. From January 27th till December 19th the battery fired 1,444 rounds; when the town surrendered

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there were still remaining 92 cast-iron and 51 steel shells. A list is given of the various kinds of shell expended :—

Common cast-iron shell	279
Naval „ „ „	313
Steel shell	275
Naval steel shell (pyroxiline)	355
Segment shell	212
Instructional shell	10

Steel and cast iron shell appear to have been supplied in about equal quantities and to have been used indifferently. Pyroxiline shells were mostly used against siege batteries. The writer considers that the Japanese were correct in their estimate of the value of high-explosive shells and that the Russian supply of this kind of shell might well have been larger.

Cast-iron shell were most popular after pyroxiline shell; a supply arrived towards the end of June, and some were borrowed from the Navy.

Segment shell were a good substitute for shrapnel, and in all the batteries they were used as such; they were nearly all expended on living objects.

Out of the 1,444 rounds expended, 657 were fired in land defence and 507 in coast defence, the large number of the latter being accounted for by the fact that Japanese torpedo boats continually approached the road-stead and carried out reconnaissances nightly.

The 657 rounds expended on land defence were used as follows :—

Against 2 Japanese batteries and troops assaulting ...	143
Against troops assaulting	491
Against a dummy battery	23

From August 7th till December 9th, *i.e.* in the course of 134 days, 343 rounds were fired at siege batteries, an average of 2½ rounds per diem. This was an inconsiderable amount when it is remembered that the Japanese batteries were firing daily and, before the assaults, at night as well, and one which could have produced but little effect. The occasions on which an enemy's battery was silenced were rare, and were probably to be accounted for by the accidental dropping of a shell into a magazine or onto a gun.

There follows a list of shells expended against troops assaulting "High Mountain" on September 6th to 10th and on November 22nd—405 in all. During assaults an alternating fire was kept up on siege batteries and assaulting columns. The number of shells fired on these occasions naturally decreased as the supply became exhausted; in the August assaults 40 shells were fired, in the assaults from 6th to 10th September 352, from 12th to 19th October 158, from 13th to 17th November 53, and on November 22nd, when "High Mountain" fell, 53. The small number of shells fired in the August assaults shows that at that period the land batteries were still able to hold their own against the siege batteries and assaulting columns.

The longest range at which an accurate fire could be brought to bear on the siege batteries was 10½ versts (12,250 yards).

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March, 1907.

RECOLLECTIONS OF THE SIEGE OF PORT ARTHUR.—The writer gives an account of his experiences in setting up search lights at Port Arthur. Traction engines and boilers from steam pinnaces had to be used for generating steam; dynamos and projectors were taken from naval vessels. In the section of which the writer was in charge a steam roller was used; the wheels were fixed on wooden shoes which were let into the ground up to the axles, and crib-work was built under the fore part. It had to work two dynamos, one for a 75-cm. projector, the other for a 40-cm. projector. The flywheel of the engine served to run the dynamo of the former; and the dynamo of the latter was run by an engine (taken from a steam pinnace) worked by steam from the boiler of the steam roller. After the first trial it was found necessary to steady the engine by concrete filling round the wheels, to resist the vibration caused by the rapid revolution of the flywheel. The writer gives details of the construction of the lights, and states how they were used for signalling at night by long and short flashes.

Some details are given about the land mines used at Port Arthur. An experiment was first carried out with an old submarine mine containing a charge of 120 lbs. of pyroxiline, wooden dummies being set up at distances of from 20 to 50 paces; the experiment showed that only the dummies within a radius of 30 paces were injured, but was on the whole considered satisfactory.

Most of the observation mines appear to have been made from the explosive portions of Whitehead torpedos. There was a deficiency of insulated wire, so in some cases an aerial line of bare copper wire had to be used, and this was naturally unsatisfactory. The writer considers that leads for observation mines should be laid at a depth of 3 to 4 feet for sake of protection from splinters, etc., and that measures ought to be taken to prevent the explosion of mines by lightning. During a thunderstorm 70 per cent. of the mines were exploded.

For the explosion of contact mines the following device was employed. The charge contained in a wooden box was set in a small hole in the ground; the detonating cap was fixed in the top of the charge with a nail in it point downwards; a small knob, held immediately above the nail by a spring, projected through the top of the box; above the latter was a board concealed by earth, one end resting on firm ground and the other weakly supported. When the board was trodden on the supports gave way and the nail was driven by means of the knob against the fulminate in the cap. Sometimes a thin board was used supported at both ends; it bent under a weight and produced the same result.

The writer gives some account of the wire entanglements used. They were of the "high" variety, but made in a rather haphazard fashion; they were usually 15 to 20 feet wide and from 100 to 200 paces in front of the trenches. Electric entanglements were tried, but were not of use in practice as the wires were always being cut by splinters. An experiment carried out on a mule was entirely successful.

A. H. BELL.

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CORRESPONDENCE.

PREVENTION OF CONDENSATION IN UNDERGROUND MAGAZINES.

SIR,

On reading the excellent paper by Lieut.-Colonel Ward, R.E., in the April number of the *R.E. Journal*, on the "Prevention of Condensation in Underground Magazines," it struck me that the proposals made in it were not unfamiliar; and getting down an old book called *Permanent Fortification for English Engineers*, by Major J. F. Lewis, R.E., published in 1890, I found the following sentences (p. 172 *et seq.*) :—

"It is necessary to have large ventilators which shall be capable of being readily opened and closed by the magazine man, according to the weather; and the openings into the magazine should be so placed as to ensure a thorough current of air passing through the magazine when they are open" . . .

"The ventilating shafts should start from the end opposite the door."

"The 9-inch glazed earthenware pipes which are often used are too small, . . .

"A better form, where there is room to carry it out, is a brick shaft about 2 feet 6 inches square in section," . . .

"A shaft of this nature has been tried on a large and damp magazine with excellent results."

I would submit that this is the same as Colonel Marshall's "revolutionary" system, described by Lieut.-Colonel Ward.

It is interesting to hear that the arrangement has been again tried with success. In time it may even be adopted generally.

I may be pardoned for thinking that this shows that *Permanent Fortification* is not yet entirely obsolete, and that it may be found to contain other useful hints for my brother officers, for whose benefit it was written.

I am, etc.,
J. F. LEWIS,
Colonel, late R.E.

The Editor, "R.E. Journal."

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The following Officers, whose names are arranged in regimental order, were successful from us at the recent Competitive Examination for admission to the Staff College.

Capt. C. Evans, R.F.A.
,, G. C. Merrick, D.S.O., R.G.A.
,, W. H. Moore, D.S.O., R.G.A.
,, J. P. Mackesy, R.E.
,, B. W. B. Bowdler, R.E.
,, F. D. Farquhar, D.S.O., Coldstream Guards.
*Capt. R. G. Parker, Rl. Lancaster Regt.
Capt. G. N. T. Smyth-Osbourne, Devonshire Regt.
Capt. V. H. M. de la Fontaine, East Surrey Regt.
Capt. and Bt. Major F. R. Hicks, Hampshire Regt.
Capt. H. S. Williams, Dorsetshire Regt.
,, B. D. L. G. Anley, D.S.O., Essex Regt.
Capt. R. S. Hamilton-Grace, Durham Light Infantry.
*Capt. H. F. Baillie, Seaforth Highlanders.
,, P. S. Allen, Gordon Highlanders.
,, J. K. Cochrane, Leinster Regt.
,, R. L. Ricketts, Indian Army.
,, W. K. Bourne, Indian Army.
,, F. W. Lumsden, R.M.A.

The following Officers received nominations:—

Capt. H. C. Bickford, 6th Dragoon Guards.
Capt. C. J. C. Grant, Coldstream Guards.
Capt. W. D. Wright, V.C., Royal West Surrey Regt.
Capt. C. H. Harington, D.S.O., Liverpool Regt.
Capt. H. Wake, D.S.O., King's Royal Rifle Corps.
Capt. and Bt. Major N. J. G. Cameron, Cameron Highlanders.
Capt. G. P. Grant, D.S.O., Indian Army.

SANDHURST, JUNE, 1906.

FIRST	A. G. Armstrong	5,541	129th	R. P. T. Ffrench	3,827
48th	H. G. Gauntlet	4,515	181st	C. W. Molony	3,445
67th	D. Macdonald	4,299	186th	P. J. I. Synnott	3,386
89th	W. G. Bagot-Chester	4,115	190th	R. M. Aylmer	3,339
90th	A. G. Ottley	4,109	197th	O. Gough	3,262
93rd	A. P. Williams-Freeman	4,094	201st	P. W. J. A. Stomm	3,151
115th	D. M. Black	3,940	213th	B. W. Molony	2,881
125th	W. J. King-King	3,846			

WOOLWICH, JUNE, 1906.

31st ... ... J. S. Barkworth 6,483

DECEMBER, 1905.

SECOND	H. G. MacGeorge	7,196	16th	R. Crofton	6,330
FOURTH	G. Walton	7,046	45th	D. Stephenson	5,899
FIFTH	H. A. Cox	6,967	54th	J. Kennedy	5,711

This was the First Examination under the new regulations, and our pupils secured THREE out of the first FIVE places.

MILITIA COMPETITIVE, MARCH, 1906.

A. E. Hardy	2,304	W. F. Anderson	1,947
N. H. Hutcheson	2,105	D. C. Robinson	1,879
F. D. Frost*	1,949	F. A. Bowring	1,876

*Read partly at the Army College, Aldershot.

ARMY QUALIFYING, 1906.

Nineteen passed.

Special Arrangements have been made for the Army Qualifying in next Examination.

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THE ROYAL ENGINEERS JOURNAL.

Vol. V. No. 6. JUNE, 1907.

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,,	IV.	**Armoured Trains,** by Capt. H. O. Mance, D.S.O., R.E.	3s. 6d.
,,	V.	**Reinforced Concrete,** by Lt.-Col. J. Winn, late R.E.	2s. 6d.

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"The Indian Volunteer Record."
"Fighting Ships."
"The Cavalry Journal."
"The Naval Pocket Book."
"The Gibraltar Directory."
"The Naval Handbook."
"The Naval and Military Review."
"The Military News of India."
"The Journal of the United Service Institution of New South Wales."

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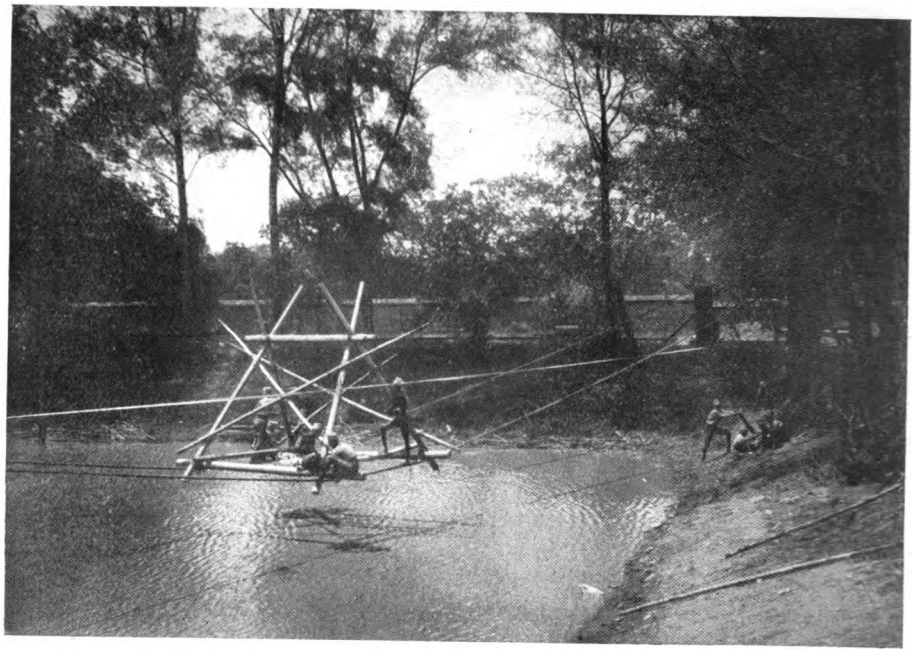
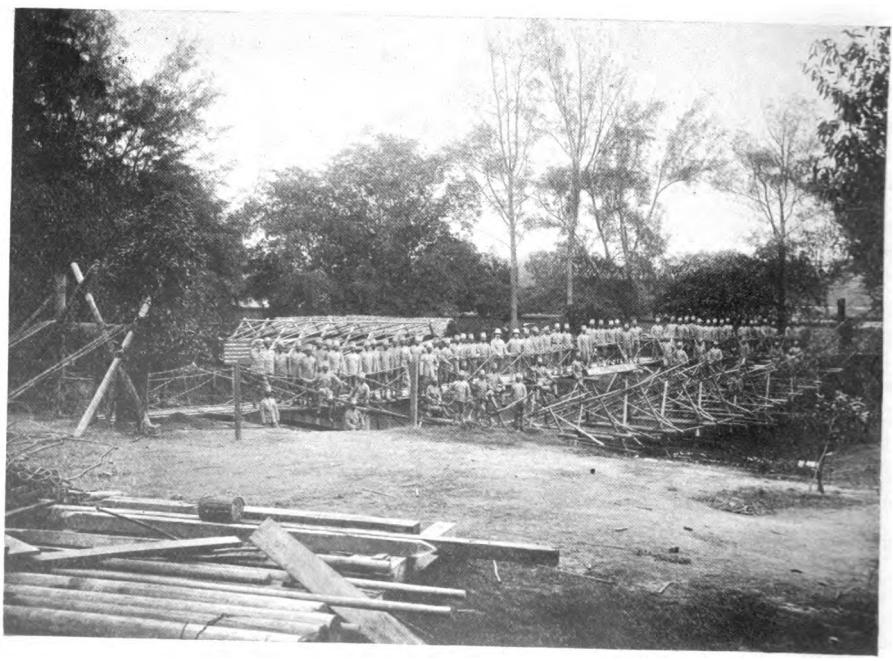
TRESTLE SUSPENSION BRIDGE, 160 FT. SPAN.

Made with Telegraph Posts by No. 10 Company, 2nd (Q.O.) Sappers & Miners.



1. The centre Trestle in position.—"L.P." posts.



2. The Bridge Completed and Loaded.

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AN EXPERIMENT IN BRIDGING MATERIAL.

By Bt. Major R. L. McClintock, d.s.o., R.E.

During the last Annual Field Works Course of No. 10 Company, 2nd (Queen's Own) Sappers and Miners, it was desired to construct a Trestle Suspension Bridge on the lines of that shown on Plate 26, Part III., *Instruction in Military Engineering*, but of 160-ft. span.

A sufficiency of suitable spars for the large number of trestle legs required not being available, it was suggested that the light poles of the Telegraph Section ("C" Company) might be utilized for the purpose.

The poles available were of two varieties :—

(1) the "L.P. (Light Pattern) Post," between 16 and 17 ft. long, made in two pieces, and weighing (exclusive of iron socket, which was not required) about 48 lbs., *i.e.* about $\frac{1}{3}$rd of its equivalent bulk in timber,

(2) the "F.S. (Field Service) Post," about 13 ft. long, made for mule transport in three pieces, and weighing about 36 lbs.

Both varieties are made of galvanized iron tubes, tapering from butt to tip, and fitting together with fishing-rod joints.

These posts being of very thin metal (especially the "F.S." pattern), it was anticipated that they would either buckle or give way at a joint when used as trestles in a loaded bridge. However, as 44 legs were wanted, and only 12 "Light" posts were available, it was necessary to use 32 of the "F.S." pattern. The former were used for the three centre trestles and the "F.S." for the remaining eight, four on each flank.

The bridge was designed to carry infantry in file or loaded pack bullocks, and the experiment was carried out quite successfully. *Photo* 1 shows the central trestle in position and *Photo* 2 the bridge loaded up after completion.

None of the posts of either sort failed, either by buckling or tearing at the joints or in any other way, though in the case of the slender "F.S." posts one or two flattened slightly where the transoms were lashed to their thin tops.

The possible use in bridging operations of this extremely light and readily portable material may perhaps be thought worthy of note by

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R.E. officers. I imagine the "L.P. Post" would stand considerably heavier loads than the above, though I am not so sure about the "F.S. Post."

DETAILS OF CONSTRUCTION.

The details of the bridge are given in case they may be of interest.

Span = 160 feet.

Dip = 1/12.

Camber = 1/30.

Height of roadway at centre above cable = 8′ 9″.

Piers were 7′ 3″ high to caps : 6′ headroom under. (Two creosoted sleepers used for each leg of these).

Number of bays = 16, each of 10 feet.

„ 2-legged trestles = 22, each 10 feet high.

„ transoms, trestle-supported = 11 } total 15.
„ „ sling-slung = 4 }

(*Note.*—The telegraph posts were not long enough to admit of the height of roadway at centre above cable being increased beyond 8′ 9″ ; so low piers, and consequently slung transoms at ends of bridge, became necessary).

Scantlings and Weights of Timbers.

The central trestles were made up as follows :—

4 legs, about 16′ long, "L.P." telegraph poles, each 48 lbs.	192 lbs.
2 transoms, 12′ long × 6″ diam., each 120 lbs...	240 „
2 ledgers, 20′ long × 4″ diam., each 42 lbs. ...	84 „
2 cable ledgers, 15′ long × 8″ diam.,* each 290 lbs.	580 „
4 diagonals, stout bamboos, each 25 lbs... ...	100 „
Total weight ...	1,196 lbs.

Roadway.

Roadbearers : 4 light railway metals (21 lbs. per yard) for each span.

Chesses : mine-casing, about 28 lbs. per foot-run of bridge.

Cables : three 3″ steel cables, stopped together with wire every foot, on each side of the bridge.

Anchors : three 12′ long × 12″ diam. logs, sunk 4 feet, at each end of bridge.

* The 6″ diameter given in the *I.M.E.* is insufficient for cable ledgers, especially in the case of "inner" frames, in which the length of cable-ledger between point of support on cable and lashing to trestle-leg is greater and bending moment consequently more.

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Total weight of trestles and roadway = 175 lbs. per foot-run. This, added to the $140 \times 1\frac{1}{2} = 210$ lbs. of infantry in file, gives a total load of 385 lbs. per foot-run of bridge.

Time and Labour: 60 men about 80 hours.

The bridge on completion proved exceptionally stiff as compared with an ordinary suspension bridge of the same span; but this appears to be its sole virtue as a type, as it is tedious to make and most extravagant of material. However, the use of jointed telegraph poles might solve a difficulty when no spars were procurable or when they could only be obtained by carting a long distance.

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ORGANIZATION WITH REFERENCE TO FIRE TACTICS.

By 'O.Y.'

IN a very interesting article in last February's number of this Journal Capt. J. W. S. Sewell, R.E., pointed out, under the heading of "Tactical Organization," the value of the 3-body system, and the successes the British Army had achieved by the use of this principle in the past; and he discussed the advantages and disadvantages of applying it not only to the organization of the larger units (such as divisions and brigades), but also to that of the smaller units (such as battalions, companies, and squadrons).

In conclusion Capt. Sewell stated his opinion that, if a convenient opportunity occurred, the organization of our army ought to be remodelled on the 3-unit system,—namely that each command should be divided into 3 sub-commands; and that this should affect even the smallest units, the companies and squadrons being divided into 3 sections and troops respectively.

As regards the application of this well-tried principle to the organization of larger units, history tells us that to it, putting strategy and generalship aside, England owes to a great extent her victories in war. However, the late Colonel Henderson, while dwelling on the necessity for all officers of learning military history, shows that it teaches only the principles of Strategy and Grand Tactics, of which the latter deals chiefly with morale and the art of command; and that, when we get into the province of Minor Tactics, we must look more carefully to the way in which modern improvements, inventions, and conditions have modified the principles of Minor Tactics handed down to us from the past.

Colonel Henderson defines Minor Tactics, distinguished from Grand Tactics, as referring to the formation and disposition of the three arms in attack and defence, and says that they concern officers of every rank; they are more or less mechanical, namely the drill movements of the battlefield, dealing principally with material forces, with armament, fire, and formations, their chief end being the proper combination of the three arms. In quoting this, I do not mean that the 3-body system is one of the principles of Grand Tactics, for on the contrary it is the foundation of Minor Tactics; but I wish to show that the conditions of the time play a much larger part in the study of Minor Tactics than in that of any other branch of the science of war.

Therefore there is no doubt that, in making the dispositions of

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troops for a battle, the first object is to do so in three lines, not only as regards the whole force but also as regards the disposition of the larger units of that force. But in considering the disposition of the smallest units other matters have to be taken into account.

I do not intend to discuss this subject at length, but only to refer to one lesson of the many which bear on the question of the organization of these smaller units.

Now, when considering the principles of the formations of a battalion, the great factor that comes into play is Fire Tactics, and in the organization of a regiment of cavalry this factor is nowadays of scarcely less importance.

We have been told that our success in war is also largely due to the manner in which Englishmen were and are able to handle and shoot their weapons. At Agincourt the English archers decided the fate of the day; in the Peninsular War the skill with which the British soldier handled and fired his Brown-Bess is well-known; lastly the Boer War showed our neglect of the effect produced by the introduction of magazine rifles, smokeless powder, and more powerful ammunition, and brought about the subsequent change in tactical formations.

Lord Roberts, in a speech after a Bisley Meeting, said "High courage, sound health, power of endurance, discipline, organization, and leading are qualities which have enabled British troops to win battles from Crécy to the present day; and though these qualities are as essential now as ever to an army which hopes to achieve great successes, yet, under existing conditions of war, they all become more or less subservient to musketry at the supreme moment of actual conflict with the enemy. However steadily and rapidly troops may have been trained to move, and however boldly and intelligently they may have been taught to take up positions, unless they are able to use their rifles with effect, when they have gained the vantage ground, they will be of little avail for the culminating point of all military training and instruction, viz. the struggle for victory between two forces, each armed with far-reaching death-dealing weapons . . ."

It is clear therefore that Tactical formations must go hand in glove with Fire formations.

One of the chief principles, upon which great stress is laid by the Chief Instructor of the School of Musketry, is the value of working in pairs and the great advantage given to Fire Tactics and their application on the battlefield by the use of the 2-unit system, that is to say of a formation in which each command is divided into two or an even number of sub-commands.

Briefly the advantages this method gives are :—

I. Mutual Support.
II. Observation of Fire.
III. Adaptability to Training.

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I. Mutual Support means the help given to one another, more especially in the attack, by individual men, squads, sections, and companies.

To get within decisive ranges without serious loss, the advance of one company must be supported by the fire of that next to it or near it; and as the time to assault is more closely reached the same principle applies to sections, squads, and individual men.

If units have been trained together and taught to rely on one another, mutual support presents no difficulty. If on the other hand they have not been so trained, it is probable that any one unit will work by itself for its own advantage instead of for that of its neighbour and the attainment of the common object.

Training in pairs gives better instruction in bringing enfilade and oblique fire to bear on an enemy's front. It is a well-known fact that men in the firing line under a hot fire rarely think of shooting except directly to their front, although more and larger targets are presented to oblique fire. Men working in pairs would not miss these opportunities, as their mutual support would give the one confidence when he knew that the other was guarding his immediate front. This is equally true of squads, sections, and in occasional cases of companies working together.

II. In the Peninsular Campaign, decisive range was 60 yards, in the Franco-German it was 250—350 yards, and owing to the increasing flatness of the trajectory of the rifle it is now 600 yards; while the new French and German bullets, although not yet issued to the troops, ensures a standing man being hit within a range of 800 yards if aim is taken at his feet. The net result of this is the necessity for accurate judging of distance. No cheap and ready range finder has yet been put on the market, nor would any range finder give the correct elevation of the rifle itself for the range; hence the only reliable way of ensuring good shooting at both short and long ranges is by efficient observation of fire.

Extended formations are now essential, and the initiative and intelligence of the individual soldier must be porportionately greater than in the past. Pairs of men working together can observe the strike of each other's bullets and better shooting is the result. This also, though in a smaller degree, applies to squads and larger units.

At longer ranges it is often necessary to employ a bracket system, termed "combined sights," and here again units divided into an even number of sub-units are more easily handled for its effective use.

III. 'Two is company but three is none' is an old proverb which applies very closely to the good training of the soldier and the efficiency of tactical units.

Of late years the principle of decentralization and the value of company and squadron training have been recognised in our army; and there are few ways which increase the initiative and keenness of

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subordinate commanders and their men as much as the system of working in pairs and the rivalry produced by the competition between the divisions of a unit.

From the above briefly noted points we see that the principle of pairs goes a long way to overcome the difficulties of modern Fire Tactics and to increase the intelligence and initiative demanded from all ranks by the introduction of scientific improvements. Also that for training purposes and working in the actual fire-fight the 2-unit system is sound when we come down to the organization of the very small units. It can be seen, by working out a diagram of the dispositions of a '9-company' battalion in the attack, that the application of this principle of working in pairs does not interfere with the employment of the 3-body system of organization, which gives us the best proportion for a reserve.

The same principle of working in pairs applies to cavalry, now armed with the rifle, and in a greater degree since the small units, on account of their mobility, are more liable to be employed in seizing and holding detached posts, and the necessity of mutual support, observation of fire, and sound training is even more important than in the case of infantry.

In conclusion we may say that the 3-body principle shows the value of dividing each division into 3 brigades and each brigade into 3 battalions, and possibly also each battalion into 9 companies and each company into 3 sections; but in the actual fire-fight the principle of pairs should be adopted.

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THE BRENNAN SYSTEM OF MONO-RAIL TRACTION.

MR. LOUIS BRENNAN, C.B., has kindly furnished us with the following particulars of his system of Mono-rail Traction, which he first made public on the 8th May last, when, in compliance with a request, he exhibited a model vehicle at a soirée of the Royal Society. His long connection with the Corps of Royal Engineers, which arose through the working of the installations of his dirigible torpedo being included in the duties of the Corps and was maintained by his long residence at the Corps headquarters at Chatham, call for the special expression in this Journal of a hope that his new invention will meet with the best possible success.

The characteristic feature of this system of transport is that each vehicle, whether it is standing still or moving in either direction at any rate of speed, is capable of maintaining its balance upon an ordinary rail laid upon sleepers on the ground, notwithstanding that its centre of gravity is several feet above the rail and that wind pressure, shifting of load, centrifugal action, or any combination of these forces may tend to upset it.

Automatic stability mechanism of extreme simplicity, carried by the vehicle itself, endows it with this power. The mechanism consists essentially of two fly-wheels, rotated directly by electric motors in opposite directions at a very high velocity, and mounted so that their gyrostatic action and stored-up energy can be utilized. These fly-wheels are mounted on high-class bearings, and are placed in exhausted cases, so that both air and journal friction are reduced to a minimum and consequently the power required to keep them in rapid motion is very small.

The stored-up energy in the fly-wheels, when revolving at full speed, is so great, and the friction so small, that, if the driving current is cut off altogether, they will continue to run at sufficient velocity to impart stability to the vehicle for several hours, while it will take from two to three days before they come to rest.

The stability mechanism occupies but little space, and is conveniently placed in the cab at one end of the vehicle. Its weight is also small.

The road wheels are placed in a single row beneath the centre of the vehicle, instead of in two rows near the sides as usual. They are

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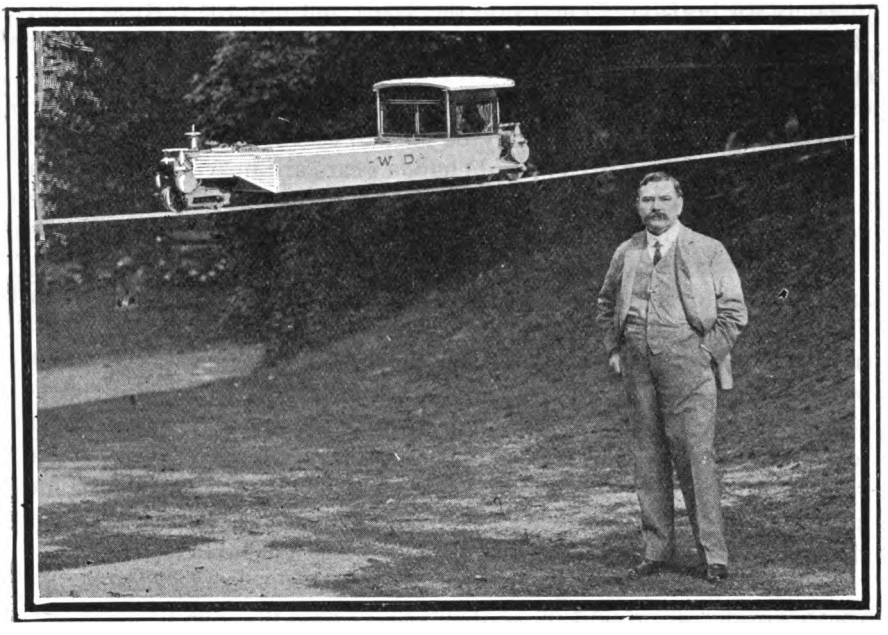
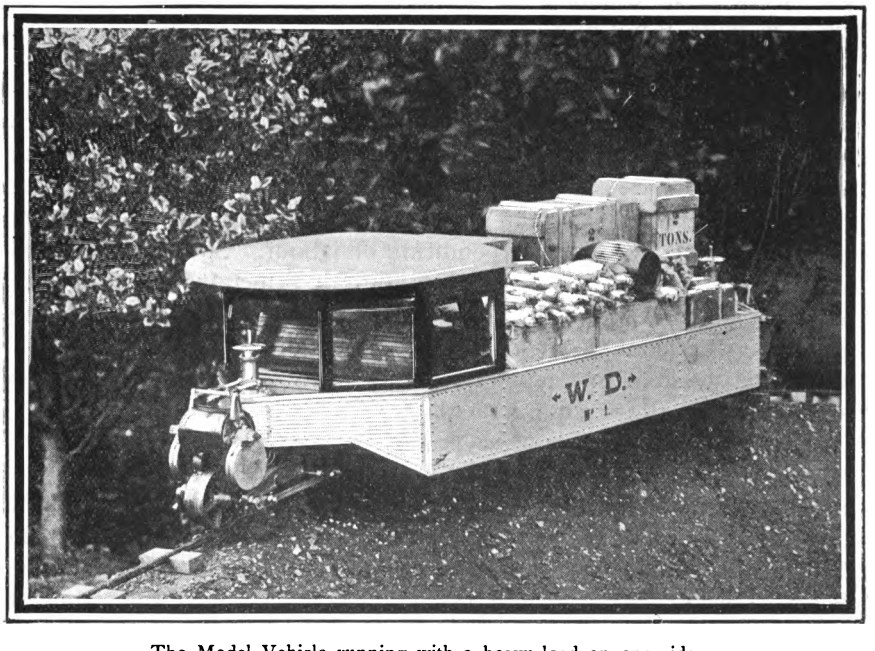


Mr. Brennan, with the Model Vehicle passing over the rope bridge.



The Model Vehicle running with a heavy load on one side.

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carried on bogies or compound bogies, which are pivoted to provide not only for horizontal curves on the track but also for vertical ones. By this means the vehicle can run, without danger of derailment, on crooked rails or on rails laid over uneven ground or on curves of even less radius than its own length.

In order that the vehicle may be able to ascend steep inclines the wheels are all power driven, and change gears are provided for use in hilly country. It is also possible to run free wheel down hill at great velocity, so that a good average rate of speed can be attained.

Brakes, capable of being operated by pneumatic or manual power, are provided for all the wheels.

The motive power may be either steam, petrol, oil, gas, or electricity, as considered most suitable for local conditions. In the first instance, however, it has been decided to use a petrol, electric generating set, carried by the vehicle itself, for the supply of current to the road wheel motors and to the stability mechanism. Such a vehicle will have the great advantage of being always ready for immediate use, the gyro wheels being kept constantly running while the engine is at rest by the current from a small accumulator.

Everything points to great economy resulting from making the vehicles wider in proportion to their length than on ordinary railways, and it has therefore been decided to make the first experimental wagon 12 feet wide, or one and a half times as wide as usual. For civil work in the Colonies the vehicles will probably be two or three times as wide, if not more.

The rail, which is of ordinary section, only requires to be the same weight as one of the rails of an ordinary line in order to carry the same load on the same number of wheels. The sleepers only require to be one half the length to give the same area of support to the vehicle.

Flying lines of railway can be laid with great rapidity over uneven ground with only a slight expenditure of labour. Specially designed construction vehicles, also on the mono-rail principle, equipped with electric gear for handling the rails, can be kept at the rail-head for the purpose. It is confidently anticipated that, working in this manner, it would be possible to keep up with an army on the march and to supply it with all its requirements.

Bridges are of the simplest possible construction, a single wire hawser stretched across a ravine or river being all that is necessary for temporary work. These hawsers can be built up on the spot from separate wire rope strands, so that the transportation of them becomes an easy matter. Strange to say the lateral swaying of the hawser does not disturb the balance of the vehicle, and the strongest winds will fail to blow it off. In other cases of bridge building a single row of piles with a rail on top suffices, or a single girder carrying the rail may be conveniently used.

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The expenditure of fuel is considerably smaller than on ordinary lines, owing to the absence of flange friction on curves and to the vehicles running without oscillation or jolting.

The speed can be from twice to thrice that of ordinary railways, owing to the smoothness of running of the vehicles and to the total absence of lateral oscillation.

Vehicles provided with their own motive power can go anywhere that a single rail is laid. Besides carrying a substantial load themselves they are also capable, on tolerably level country, of supplying current to other vehicles unprovided with power-generating plant, thus running as trains.

It must not be understood from the foregoing that the utility of the invention is confined to vehicles of the dimensions described. One of its most valuable applications will consist of its adaptation to vehicles of more ordinary dimensions, which will serve on feeder lines to the existing railways or on pioneer lines in new countries such as the Colonies. By this means it will be possible to construct lines at the minimum cost, and give settlers a means of getting their produce to market with great speed and economy. For such work the vehicles will be provided with gears which will enable them to climb, heavily loaded, the steepest inclines, thus doing away with the necessity for cuttings and embankments, the cost of which would be quite out of the question in such localities.

The advantages claimed for this system may be summed up as follows :—

Small first cost and cost of maintenance. This is obvious as only one rail is required, and the line need be only half the ordinary width or even less. Moreover, as the vehicles can negotiate steep gradients much work will be saved in the matter of tunnels, cuttings, embankments, and bridges.

Saving of material required for construction of line in the way of rails, bridges, sleepers, etc.

Capability of vehicles taking curves.—The fact that the vehicles lean inwards to the correct angle when taking curves secures them from derailment at the highest speeds.

Large carrying capacity of vehicles.—It is certain that for high-class transcontinental lines the vehicles will be very large compared with those on existing railways. Besides the advantages connected with passenger traffic, great advantages will also arise in the transport of goods and materials, as many commodities can be carried in bulk instead of in small parcels as they are at present.

High Speed.—Very high speeds are expected to be attained on high-class lines laid on this system, owing to the total absence of the lateral oscillation which is caused on ordinary lines by

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the impossibility of laying two rails exactly level and parallel with each other. From twice to thrice ordinary railway speeds are to be expected.

Less Fuel Consumption, owing to absence of flange friction and of oscillation.

Perfect comfort in travelling, owing to there being no oscillation.

Safety.—Travelling will be much safer owing to the absence of danger of derailment at high speeds.

Mr. Brennan's early days were spent in Australia, when his personal experience of the hardships of travel over the rough tracks of that country led him to consider what might be achieved in the way of ideal travelling, if man could discover how to rightly apply the materials and sources of nature to the purpose. Leaving aside the larger question of aerial flight, and confining himself to travel on the surface of the earth, it seemed to him that the simplest and most ideal roadway would be a single rail laid on the ground. But there appeared to be practical limitations to the use of such a roadway, since the centre of gravity of a vehicle travelling on it would have to be above the points of support and would have to balance itself against such upsetting forces as a shifting of the internal load, varying wind pressures, and centrifugal force when passing over curves.

Under the stress of perfecting his dirigible torpedo, there was little time for the inventor to follow up his idea of railway transport. But, whenever opportunity offered, he returned to the subject, and carried out experiments in balancing unstable bodies. Moving internal weights, etc., did not yield any results, and the first system that seemed to offer a possible practical solution was to react on the inertia of a fly-wheel of which the axis was parallel to the rail. It is evident that a torque to oppose any upsetting force can be obtained by this means; but, on experiment, the difficulties in the way of arriving at a complete practical solution on these lines proved to be so great that recourse was had to other methods.

Mr. Brennan next turned his attention to studying the gyroscope, as it seemed possible to him that a solution of the problem might be found hidden in this instrument which behaves in apparently so paradoxical a manner.

The principle on which it works can be seen and studied in a spinning top, and anyone who studies such a top will find how different all its movements are to those with which we are familiar. This principle is called the gyrostatic action of rotating bodies, and is unquestionably the most difficult to explain, as it is to understand, of all the movements known in mechanics.

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It is not proposed to enter into a detailed description here, but reference to *Fig.* 1 will give a rough idea. Suppose A to be a fly-wheel with its axis in pivots in a circular frame B.

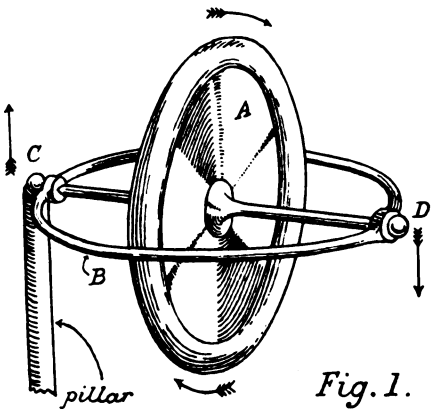

Fig. 1.

If the wheel is made to spin rapidly in the direction shown by the arrows, and the end C of the axis is placed in a hollow or cup at the top of a pillar so that the wheel is spinning in a vertical plane, the axis of the gyroscope will not, as might be expected, rotate in a vertical plane owing to gravity pulling down the end D.

But the axis will rotate in a horizontal plane. The end D will come forward (*i.e.* towards the reader), because the wheel always tries to place itself so that its spin will be in the same direction and the same plane as the couple tending to rotate the axis. This movement is called the 'precession' of the gyroscope. (The direction of the precession can be reversed by spinning the wheel the opposite way, or by supporting the other end of the axis).

If this natural rotation or precession is assisted by any external force (*e.g.* the hand), a torque will be produced which will actually raise the end D of the axis of the gyroscope. This assisting force will thus be doing work against gravity, although it is applied in a horizontal plane; if it is continued long enough the gyroscope will rise until its axis becomes vertical, thus placing itself in a position of equilibrium.

The principle on which stability can be maintained can therefore be summarized thus:—Accelerate the precession of the gyroscopic wheel and a torque is obtained in a plane *at right angles* to that in which the wheel is revolving.

Fig. 2 is a rough diagrammatic sketch to illustrate the principle of the stability mechanism in the Mono-Rail vehicle; but the diagram is incomplete in some important details.

As both vertical and horizontal curves have to be dealt with, there are two gyroscopes or fly-wheels, rotating in opposite directions, the

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axes being normally parallel to the axles of the road wheels; the two fly-wheels are so geared as to produce a combined effect, which prevents curves on the line interfering with the stability-giving power of the mechanism. The actual position of this mechanism is immaterial; it may be in the cab in the front end of the vehicle (as in the model), or under the centre of the floor, or at the back end.

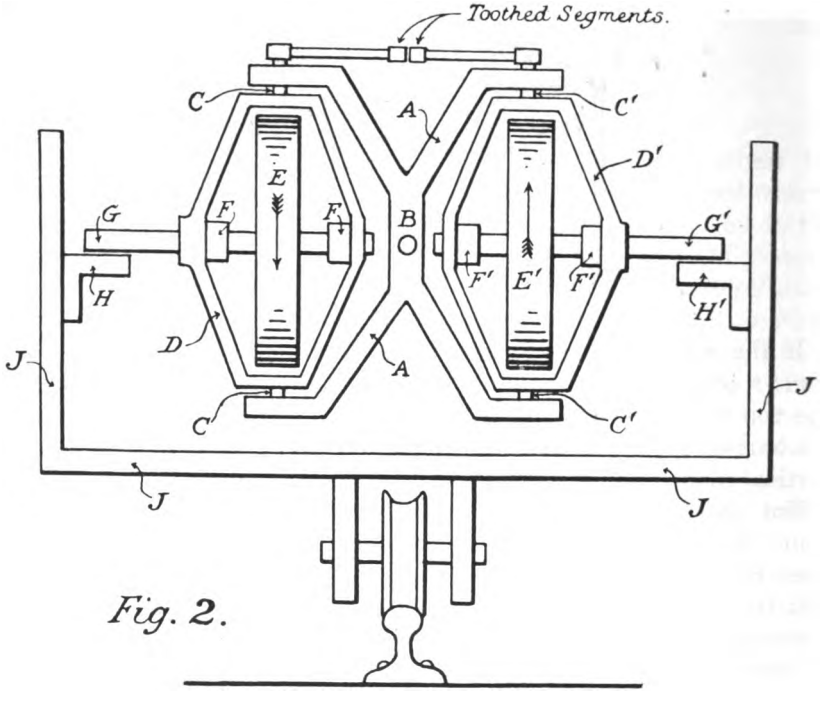

Fig. 2.

In the model the main frame (A) of the stability mechanism is carried on trunnions (B) which are longitudinal to the vehicle, the trunnion bearings being fixed to cross-way partitions or bulkheads. On this main frame are pivoted, on vertical trunnions (C, C, C′, C′), the vacuum cases (D, D′) which enclose the fly-wheels (E, E′) and also carry their bearings (F, F, F′, F′). The ends (G, G′) of the axes project from the vacuum cases. Fixed to the body (J, J) of the vehicle are segmental brackets (H, H′).

The action that occurs when an overturning force is brought to bear on the vehicle is as follows:—The main frame of the stability mechanism, being trunnioned fore and aft, is prevented by the gyroscopic action of the fly-wheels from tilting with the vehicle, and the projecting end of the axis at the rising side of the vehicle comes into contact with its corresponding bracket. Two effects are then produced. Firstly, the bracket presses against the axis of the fly-

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wheel (E) and thus tries to disturb the planes of rotation of the fly-wheels. This causes the fly-wheels to precess, *i.e.* to rotate on the trunnions (C, C, and C′, C′), and owing to this precession they resist any tendency of the vehicle to yield to the upsetting force. Secondly the rotating axis (G), pressing against the bracket (H), is caused by friction to roll along the bracket and to accelerate the natural precession of the fly-wheel. This acceleration of precession causes the axis of the fly-wheel to press on the bracket (H) with a greater force than that tending to overturn the vehicle, and thus brings the vehicle back into a position of equilibrium.

The actual arrangement used by the inventor for automatically controlling the precessional movement of the fly-wheels is of a more complicated character; the exact details have not yet been divulged. The mechanism is fully covered by numerous patents in all the principal countries.

The model exhibited is 6 ft. long, and contains two 5-inch diameter fly-wheels, running at about 7,000 revolutions a minute. The motive power for all purposes is obtained from a small secondary battery, the power required to drive the fly-wheels being only a small proportion of that required to drive the road wheels of the vehicle. In the full-sized experimental vehicle, now under construction, which is to be about 40 feet long and 12 feet wide, and expected to carry 20 tons, the fly-wheels will be 3 ft. 6 in. in diameter. In the full-sized vehicle 5% of the gross load is considered an ample allowance for the weight of the fly-wheels. But it is anticipated that in standard ones this amount will be reduced to 2%—3%; and that all of this weight will be saved by reduction of weight in other parts of the vehicle, so that the proportion of tare to weight carried will be less than in any existing form of railway wagon.

The model, fully loaded, successfully negotiates gradients of 1 in 5, turns almost within its own length, and has carried a 10-stone man over a wire rope stretched across a span of 50 feet. It thus demonstrates clearly the practicability of the system on a small scale, and gives every evidence that on a large scale the results will be even better and that it has before it a very great future.

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DESIGN OF STABLES AND ACCESSORIES IN SOUTH AFRICA.

By LIEUT. B. H. WILBRAHAM, R.E.

Climate.

THE following notes refer only to stations situated on the high veld. All garrison towns in South Africa are on the high veld, with the exception of Cape Town where the barracks were constructed many years ago.

The first point to consider is the climate. As a rule in South Africa it does not rain. When it is wet, the rain comes down in torrents, and clears up again quickly. Ordinary English drizzle and fog for days and often weeks on end are practically unknown. For several months in the year there is no rain at all, but frequent high winds, causing dust storms. In summer the sun is very strong, though it is not nearly so overpowering as in India. Also all the year round there is a very great difference in temperature between day and night—sometimes a range of 50° or 60° F. in twenty-four hours.

Horses are very liable to a chill if taken out on a cold night or morning from a warm stable. Hence stables should not be too warm.

Requirements.

The requirements to meet the altered climatic conditions in South Africa are :—

(1). Protection from sun.
(2). „ „ rain.
(3). „ „ wind and dust storms.
(4). Temperature in stable to approximate to that of air outside.

Local Usage.

Before going further it is worth considering what the inhabitants of the country do. A common type of stable used by the farmer consists of a stone kraal about 20 yards square with an open shed along the windward side. One or both ends of this shed are roughly enclosed to form loose boxes (*Fig.* 1).

Sometimes the kraal is only about 24 feet wide. In this case the shed occupies about half (*Fig.* 2). One end of the shed is enclosed as above, and the other end forms a somewhat larger box.

If the sheds are used as loose boxes the entrances are closed by slip rails. Frequently they are not closed at all, so that the horses can wander at will over the whole kraal.

In either case the shed is of the roughest description. There is no attempt at drainage, and the dung and stable litter are left untouched. Perhaps once a year, if the farmer is energetic, the stable is cleaned out. Owing to the sun and free circulation of air these stables are

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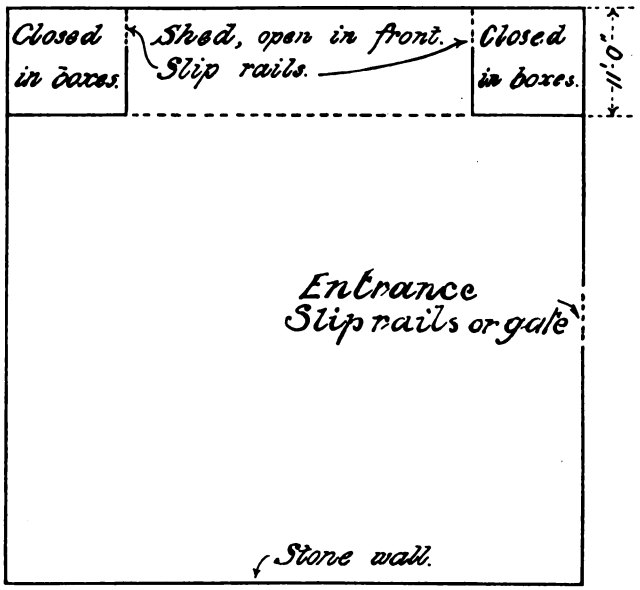

FIG. 1.

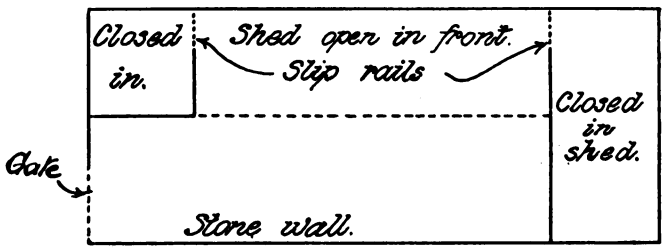

FIG. 2.

not so offensive as might be expected. The horses seem to thrive in this type of stable, and do not suffer from "thrush" or other diseases of the foot which the state of the floor might be expected to produce.

STABLES BUILT BY R.E.

As the cantonments were built out of wood framing and corrugated iron, these being considered the most economical materials, the stables were made similar. They were not lined with match boarding or rough boarding.

Had the barracks been built in masonry or brickwork, the stables and accessories would most likely have followed suit. Whether this would have been to the advantage of the horses is doubtful, as the stables would have been too warm at night. In South Africa troops may be required at very short notice for active service in the country. By being kept in open stables horses become much hardier and are always fit to be taken out 'on trek' at once.

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The stables built by the Royal Engineers at Bloemfontein, O.R.C., may be divided into four classes :—

(*a*). Small Stables.
(*b*). Troop Stables.
(*c*). Mule Kraals.
(*d*). Remount Depôt Stables.

(*a*). SMALL STABLES.

Separate stables were provided for the following :—

(1). Groups of four or five married officers' bungalows. The stables were placed as centrally as possible.
(2). Individual bungalows.
(3). Battalion of Infantry.
(4). Field Company and Supernumerary Staff, R.E.

Those prepared for (1), (3), and (4) were of the same design, and those for (2) considerably smaller. Looked at from home standards and compared with the *Barrack Synopsis* there seems to have been a very lavish provision of stabling. It should, however, be borne in mind that in South Africa it is almost essential for every officer to have at least one horse, and for a married officer to have a horse and trap or Cape cart and pair of mules.

Another consideration was that the rent charged by the War Department for the bungalows was very high, so that efforts were made by the R.E. in the country to give as much accommodation as possible.

The type of stable provided for (1), (3), and (4) is shown in *Fig.* 3. The whole of the front was open. There were 12 stalls, 10′ long and 6′ 6″ wide with wooden partitions. In front of the stalls was a 4′ 6″ passage.

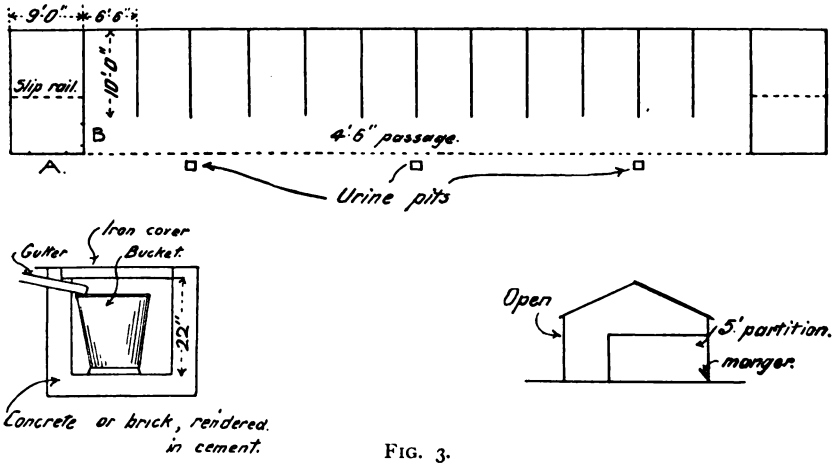

FIG. 3.

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In the R.E. stables the ends were used as loose boxes with doors at B, hung in two parts. Across the middle were slip rails to form two loose boxes. In Infantry and bungalow stables doors were placed at A, so that the end part could be used either as a coach house or a forage store.

The floors were of concrete, currented to carry off the urine. There being no water-borne sewage system, three urine pits (*Fig.* 3) were provided. Surface drains were constructed quite independent of the urine gutters, so that there was no fear of the urine pits being flooded out after a storm.

These stables were placed more or less north and south, so that the back was towards the west or prevailing wind.

The type provided for (2) was of course much smaller. The most satisfactory pattern erected is shown in *Fig.* 4. These stables were usually built in pairs.

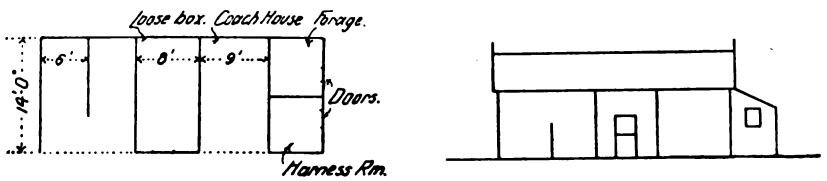

FIG. 4.

Earth floors were tried, but were not satisfactory. Sometimes a concrete floor was provided, but this seems an unnecessary expense. Another form was suitable if well done. Roughly squared cobbles were carefully laid, then grouted in with cement and floated over to a smooth surface. This kind of floor was not currented as usual in stables, but laid with a very gentle slope from the horses' heads outwards.

In addition to the stable in (1) another building, containing 4 separate forage stores, 4 harness rooms, and a common room for general use, was provided. Thus each of four bungalows had its own separate forage and harness rooms. The grooms usually slept in the latter room. The two buildings were placed parallel and about 25 yards apart, thus enclosing a yard, the sides of which were fenced in.

The stables in (2) were usually inside the general bungalow enclosure, thus doing away with the necessity of enclosing a yard.

The R.E. stables and yard were arranged as shown in *Fig.* 5. This was very convenient while mules were used for draught purposes. When draught horses were issued and the mules withdrawn the necessary accommodation was provided in the cavalry lines, where a stable was shared with its proper occupants. This course cannot be recommended. If a 40-horse stable had been erected in place of the existing one the arrangement would leave but small scope for improvement.

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In these open stables it is very necessary to have the whole enclosed in a yard, so that if a horse does break loose he cannot stray.

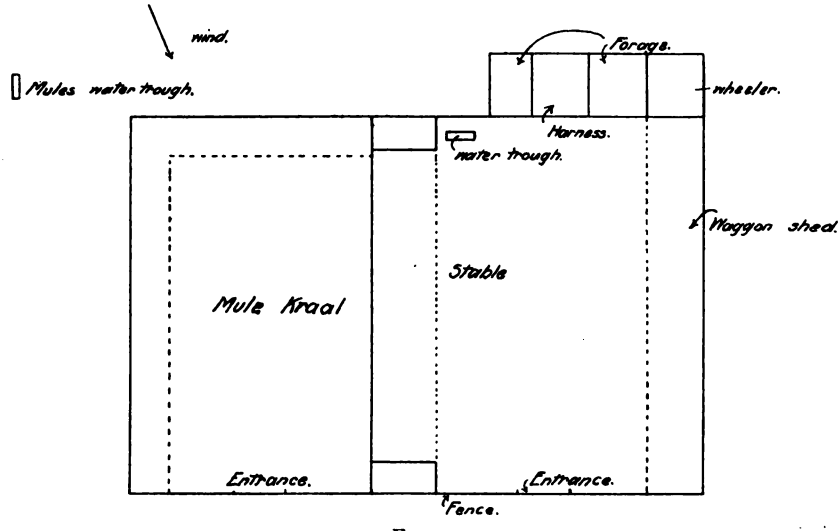

FIG. 5.

(*b*). TROOP STABLES.

Troop stables were built closed in, but more lofty than the above and with numerous ventilators and hinged flaps. One type for 76 horses had four doors, one at each end and one in the centre of each side, with a passage down the middle (*Fig.* 6).

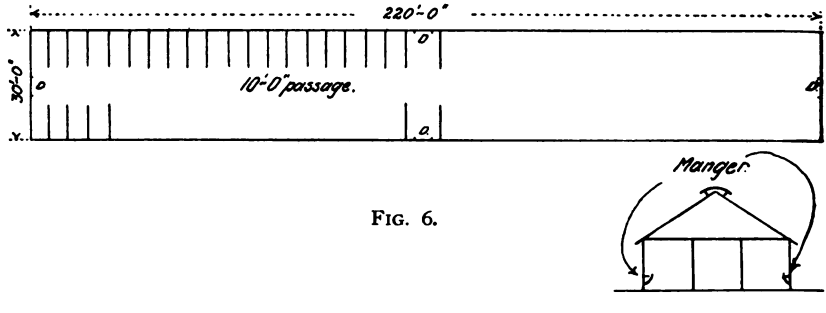

FIG. 6.

The stalls were built according to *Synopsis*, with swinging bales between. Six or seven per stable had wooden partitions instead of bales to accommodate kicking horses.

In front of each stall there was a flap hinged at the top and kept open by a stay similar to a large casement stay. In warm weather these hinged flaps were always kept open. Thus there was an almost continuous open space about 2 feet wide all round. As the bottom

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of the flap was level with the top of the manger, the hay was often blown out or strewn by the horses. To remedy this a couple of bars were put across the open space. In addition there were windows, hinged at the bottom, above each stall, about 7 ft. from the ground, opened by a fan-light opener. Ridge vetilation was provided along the whole length of the building.

The floors were of concrete and currented to urine pits round the building.

A great objection to this type of stable is the small number of doors in case of fire. In this class of construction fire is a much more important factor than in other types. When once a wood and iron building has caught fire it is hopeless to think of saving it. Of course more doors might be put in, but at the expense of the stalls.

In another type erected the horses' heads were turned towards the centre and there were three passages (*Fig.* 7). Putting out feeds from the central passage was thus very much simplified. There could be any number of doors without sacrificing any of the stalls; about six a side were usually put in.

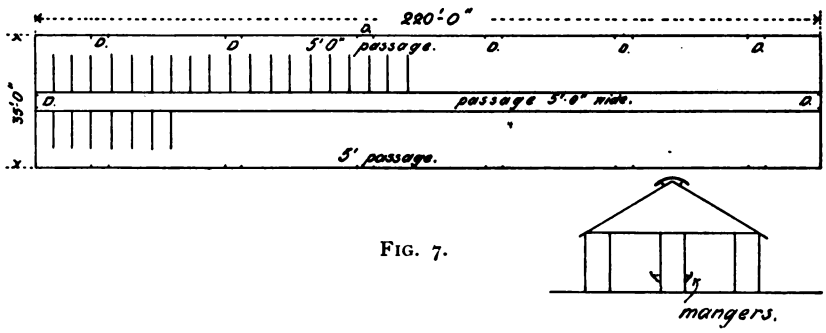

FIG. 7.

Where there were not doors there were either windows or hinged flaps. Accordingly there was no place for diagonal bracing, and the building must have been very weak longitudinally. None ever showed signs of giving way, so perhaps they were really strong enough.

The units who had this type of stable liked it very much. The cost was, however, about 20% per horse more than in the other pattern.

Both these stables were too large, as they were for two troops. It is much better if possible to make stables for one troop only, *i.e.* for about 40 horses. As the establishment is always altering it is well to provide a few stalls in excess of the existing establishment. The best type would be a 40-stall stable with four doors as in *Fig.* 6. Then an officer's stable could be provided in addition; this was not done in South Africa.

In all these buildings great care had to be taken not to leave any sharp sides or ends of galvanized iron sticking up, especially about the

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mangers. Another point to look to is that all woodwork must be protected from being gnawed by the horses. One method is to cover with galvanized iron all wood that is liable to be gnawed. Another is to creosote the wood frequently; sometimes veterinary officers insisted on this from a sanitary point of view.

Iron bales as used at home were not available, so that wooden ones had to be improvised. 9″ × 2″ deals, covered with galvanized iron sheeting, proved satisfactory.

WAGON SHEDS AND OTHER ACCESSORIES.

Brick dung pits were put up close to each of the above stables. There being no other means of disposal of the stable litter it was burnt in the pits. Hence these pits were always kept at some distance from forage or litter sheds.

Litter sheds, open in front and with concrete floor, were placed between stables.

A good form of water trough was made out of masonry and concrete (*Fig.* 8). This was slightly cheaper than the cast-iron variety in use at home, and has the additional advantage of being practically unbreakable. When mules crowd round a trough they often charge into it or lean against it, and generally one or two try to get into it, especially if very low.

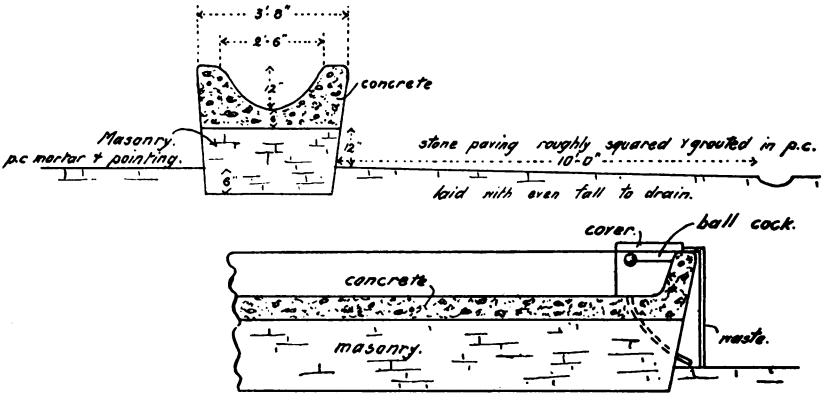

FIG. 8.

One or two wagon sheds of local design were put up, but were not satisfactory. They should be exactly as laid down in the *Synopsis*, but adapted to corrugated iron construction. To protect the back wall from vehicles being run in carelessly, good stone or concrete kerbs should be provided. The kerb should be as near the back wall as the vehicle permits, so as not to waste any room. Of course the kerb for a gun is much further forward than that for a wagon.

There is no particular point about forage sheds. They should not

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be placed to windward, but in some convenient place where they will do least damage if they catch fire.

In the cavalry lines one harness room per squadron was allowed. This was invariably used as a squadron office, which shows that its provision is not essential. As the authorities at headquarters do not sanction the construction of squadron offices it seems desirable to continue to provide harness rooms, or suchlike recognized buildings, which can be used by the regiment as offices. Perhaps this is a wrong way to look at the subject—all the same it adds materially to the convenience of the troops occupying the lines.

Forges should have plenty of fresh air. It is very trying to a farrier to work all day in summer in a stuffy forge. A type of forge which proved very satisfactory is shown in *Fig.* 9. Both sides of the building were open. The floor was made of ant heap and sand, laid like cement. It was floated off with ant heap and breeze and the surface consisted of cinders.

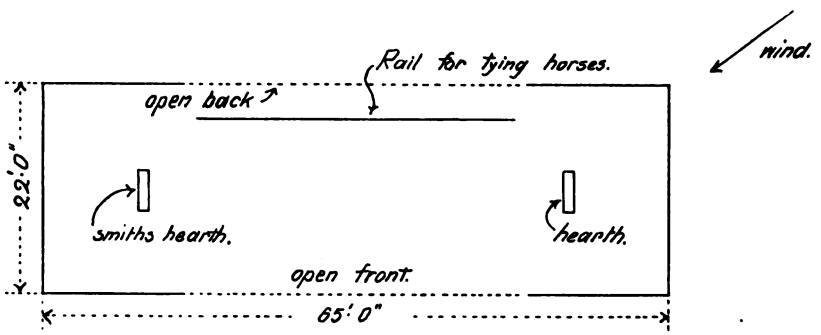

FIG. 9.

Great care should be observed in laying concrete floors for stables. They should be covered with sawdust and kept wet to avoid too rapid setting. If possible they should not be used for six months. If used within six weeks, they will nearly always break up in a very short time.

The stables in question were all sited as much as possible to leeward of the lines, so that any stable litter blown about would not come through the lines. They were also kept as far as possible from kitchens or dining rooms and officers' mess and quarters, the object being to prevent contamination of food by flies which swarm round stables in hot weather.

(*c*). MULE KRAALS.

Mule kraals were of much simpler type than the stables for horses. They consisted of a stone kraal with dry rubble walls, 5 or 6 ft. high (*Fig.* 10). An open shed—about 2 or 3 ft. run per mule—was put up round the kraal, the roof sloping outwards so as to carry the water away from the enclosure. Either the wall was carried up to the roof

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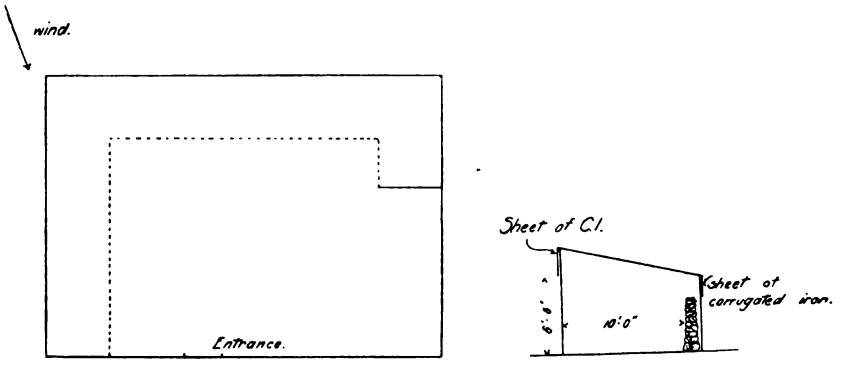

FIG. 10.

or else corrugated iron was carried down the side of the shed to give protection as far as possible. In either case a gap at least 10″ wide was necessary just under the roof; this allowed the wind to pass through and reduced the liability of the whole shed to be blown over.

A very important point is to protect all woodwork from being eaten by the mules. Many mules prefer eating wood which has been tarred or creosoted. Every part of woodwork which is within reach of the mules should be covered with galvanized iron. A good method for protecting the uprights is to wrap hoop iron round them from 1′ 6″ from the ground up to 7 ft. Barbed wire should not be used as it forms an irresistible attraction to a mule to scratch himself on; and this action will in course of time bring the whole shed down.

(*d*). REMOUNT DEPOTS.

The stabling required for remount depots comes under quite a different category to that hitherto dealt with. The first consideration is economy. The garrison in South Africa was continually being changed, and so the Remount Depôt also suffered many changes, both in establishment and site. During 2½ years some of the sheds were taken down and re-erected on four different sites. This was an additional reason for economy in design.

For economy in working the staff must be as small as possible. The horses must be exercised and kept fit for use at once. There must be means of dividing up the horses into different classes, and also of isolating them should any epidemic break out at the depot.

Hence the essentials are :—

(1). Economy of construction.
(2). „ maintenance, with means of easily exercising horses and separating them.
(3). Adaptability of buildings for re-erection.
(4). Protection from sun, rain, and wind.
(5). Water laid on to troughs, and plenty of the latter.

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Remount Stables erected were based on a scheme devised by Capt. (now Major) Eassie, A.V.D., which he worked with great success during the war.

A, B, C, and D (*Fig.* 11) are open sheds with their backs to the prevailing wind. Each stable has its kraal in front, fenced in. Water is laid on to the troughs W in each kraal. There are slip rails at *g*, which open on to a road along the front of the line of kraals. E is an exercising ring, about 600 yds. in circuit. Each of these kraals will accommodate about 100 horses.

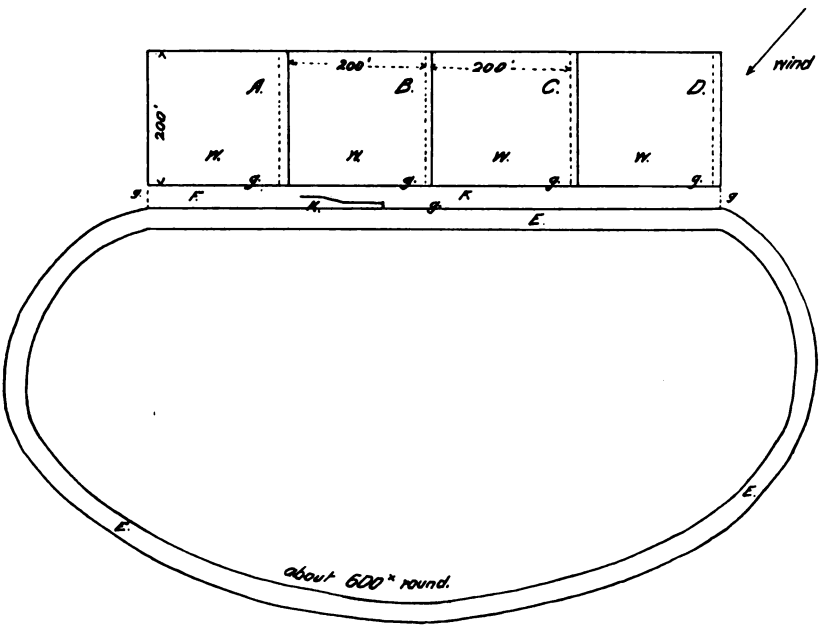

FIG. 11.

As a rule the horses were not tied up, but free to go about the kraal as they liked and to drink when so inclined. To exercise them the slip rails were removed, and they were driven into the exercising ring and then round and round that until they were sufficiently exercised. They were then driven back to their kraal and a fresh lot exercised. Thus all the 400 horses could be exercised by half-a-dozen 'boys' in the course of a morning.

A new horse is sometimes rather free with his heels in a kraal like this, but steadies down very quickly. Altogether there were remarkably few injuries from kicks. Capt. Eassie claimed that this was by far the best way to make horses quiet to handle.

If it was necessary to catch up a wild horse which would not let himself be caught in the kraal, he was driven into the crush K (*Figs.* 11 and 13). Often a dozen other horses had to be driven through it to include the one required. At the end of the crush is a long narrow

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passage, in which the horse could be quickly caught up by the 'boys' standing beside it. This part of the crush was also very useful to mallein horses in.

The stables were of section as shown in *Fig.* 12. Rings were bolted to the mangers, so that horses could be tied up if required. The floors were made of a gravelly earth, and sloped slightly from the mangers. They needed a certain amount of supervision and maintenance in the cartage of more sand or earth from time to time to fill in holes.

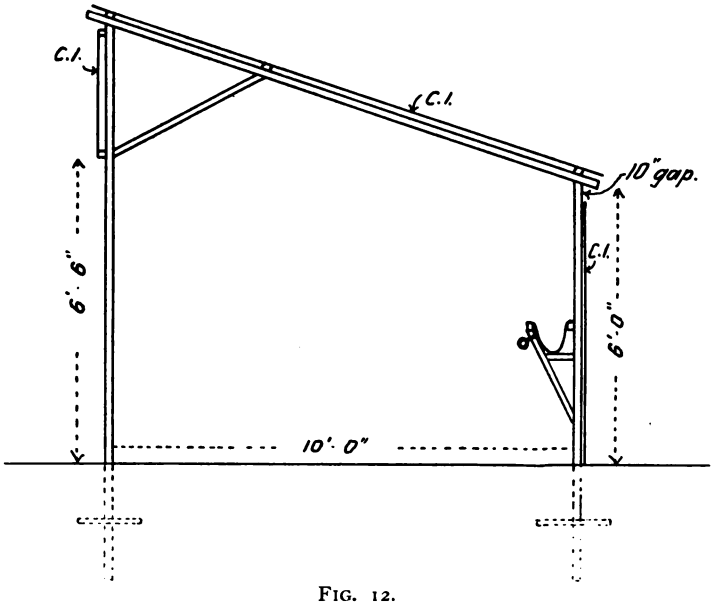

FIG. 12.

To prevent the posts being torn out of the ground by the wind, a couple of pieces of old scantling, about 1 ft. 6 in. long, were nailed across the upright under ground. Also hoop iron was put on over the rafter and purlin, binding them on to the uprights. As in the mule kraals a 10″ gap was left for the wind to escape by. These were very necessary precautions to withstand the wind pressure when it got under the roof.

The crush was 4 ft. 6 in. high, and made of 9″ × 3″ or 6″ × 3″ timbers bolted together and with the bolts flush with the timber. All angles of the scantlings were slightly rounded or chamfered to prevent splinters or chance of injury to the horses. Along the outside was a step about 1 ft. high for the boys to stand on when catching a horse, and at the end was a gate for diverting the horses into E or F (*Fig.* 13). The two projecting walls are to prevent a sudden backward rush of wild or timid horses when they see the narrow passage in front.

Sick lines for the depôts had sheds similar to those above. They

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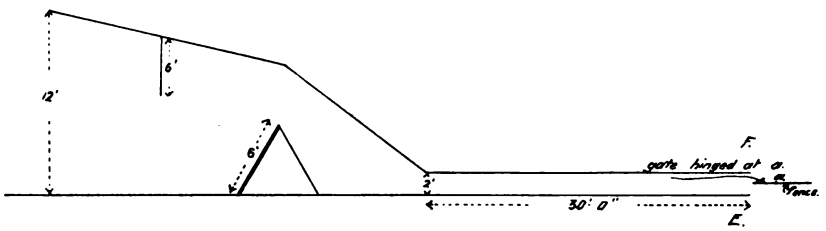

FIG. 13.

were made in 6-ft. bays, so that one bay would make one stall or two could be converted into one loose box. A certain number of loose boxes were provided; they were boarded in all round and had two doors hung in two. The sick lines were divided up into separate groups of stalls or boxes for eight or ten horses, each group with its wire kraal and troughs.

Close to the sick lines were two isolation or segregation paddocks where suspicious cases could be kept under observation. They each had their troughs and water laid on.

The fencing used throughout was "Lamb's Fencing" on wooden posts. It is also called "wire wove fencing" and is an American supply. It is practically a glorified rabbit wire.

In addition to the above stabling the whole farm was divided by barbed wire fences into paddocks for grazing purposes. In each paddock water troughs were fixed and shelters similar to the sheds but without the mangers. (These shelters were limited owing to lack of funds). Water was laid on to all the troughs, which were fitted with a ball-cock in a box at one end. About $5\frac{1}{2}$ miles of piping—chiefly 2″ and $1\frac{1}{2}$″—were required to supply water to all these troughs.

The cost of the sheds as above described is $\frac{1}{8}$th to $\frac{1}{10}$th that of the stables in (*a*) and (*b*) per horse. This principle of Major Eassie's seems to be a very sound one, and well suited to South Africa.

In this article the subject of permanent Sick Horse Lines has not been treated. When the writer left South Africa the design had not been decided upon, nor did there seem to be much prospect of any funds being provided. A design after the type of the Remount Depôt —only not so rough—was being discussed.

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*THE VITAL POINT OF AN ARMED FORCE.**

By MAJOR C. ROSS, D.S.O., *p.s.c.*, NORFOLK REGIMENT.

COLONEL HENDERSON, in *The Science of War*, tells us that war is no exact science, that it has no fixed code of rules, that there is but one good working principle, viz., the concentration of superior force, physical and moral, at the decisive point.

Most of us have, by this time, learnt this principle off by heart; those of us whose duty it is to teach never lose an opportunity of impressing it on our pupils. Concentrate, concentrate, we urge, concentrate at the decisive point. But if we are asked where the decisive point is to be found, many of us become slightly incoherent.

The truth is, that it is very often a matter of exceeding difficulty to say which is the decisive point; it is sometimes as difficult to discover it as it is to find the key of a position. Yet that the principle is true is beyond doubt; for all history tells us that the application of overpowering force is the one true principle of success in war, that it holds true of the national strategy which directs nations, of the strategy which directs armed bodies in the theatre of hostilities, and of the tactics of the battlefield. It is important to go into this question; for the knowledge of any principle is obviously useless unless we also know how to apply it.

A decisive point has been defined for us as one the possession of which gives a tremendous advantage to that force which is able to seize and hold it.

We can easily understand that, in a war between an island power and any other, the sea between the two nations constitutes a decisive point, the command of which will enable its possessor to strike at its adversary—to strike a deathblow if overpowering force is available. We can also easily recognise that, if an island power holds continental territories which are threatened by a continental power, the sea is no longer necessarily a decisive point. Thus, as regards Russia and Japan, the sea, at the outset of the late war, was the decisive point; and the command of it enabled the Japanese to strike at Port Arthur and at the Russian armies in Manchuria. The Japanese, having firmly established a temporary control of the sea, the decisive point

* Lecture delivered at the School of Military Engineering, Chatham, on 14th March, 1907.

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was transferred to land, to the point of contact between the hostile armies. But when the Russians prepared a fleet in home waters to again contest the command of the sea, it appeared probable that the sea would again become the decisive point. The Japanese therefore determined to obtain possession, at all costs, of Port Arthur—a possible refuge and base of operations for the new Russian fleet. It was Port Arthur which was now the decisive point. It was, in fact, far more of a decisive point than its mere value as a harbour of refuge and base of operations—in both of which capacities it left much to be desired—would warrant; and, in attacking it, the Japanese would seem to have struck at the moral, or national, spirit of the Russian nation. Its capture, we notice, was instantly followed by serious disturbances in Russia. Now that the Japanese hold Korea and Manchuria, the sea is no longer the decisive point; it has finally, it appears, been transferred to the land, for it is very unlikely that the Japanese will ever again permit the Russians to establish a naval force in the Far East.

And so, similarly, in the case of two continental powers, such as France and Germany, the decisive point lies, not on the sea, but on the land frontiers, in the great fortresses which block the communications between the two countries, or, possibly, in neutral territories by means of which those fortresses can be turned. But the possession of these decisive points is, in itself, in no way decisive; the deathblow remains to be struck. The Battle of Mukden, for instance, had to be fought after Port Arthur was captured.

As regards an army in the field, the selection of the decisive point becomes still more difficult. We can easily understand that a junction of roads, or a passage over an impassable obstacle, the possession of which grants the holder great freedom of action, or enables him to strike at his adversary's communications, or to separate the hostile forces, may constitute a decisive point. But, here again, the possession of such a point, though it grants an opportunity for the delivery of a deathblow, is not, in itself, in any way decisive; the major part of the business, the actual delivery of the deathblow, remains to be accomplished.

Thus Napoleon, in the Waterloo Campaign, having concentrated secretly, seized suddenly on the line of communication between the allied armies, a decisive point, the possession of which enabled him to strike at the allies in turn. Having defeated—routed, as he appears to have believed—the Prussians at Ligny, he delayed his pursuit, fearing lest a vigorous pursuit might drive them northwards to Wavre, and so towards Wellington's army. He then turned leisurely against Wellington, in the belief that the Prussians were in full retreat on Prussia. The Prussians, however, were in full march on Wavre to assist Wellington. It was now the passage over the Dyle at Wavre which had become the decisive point, the possession of which would

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grant an inestimable advantage to its holder. The Prussians seized it, and were thus able to intervene with decisive effect on the field of Waterloo.

In the Salamanca Campaign, Marmont, having outmarched and outmanœuvred Wellington, threatened the latter's communications; but when, overconfident, he sought to utilise his advantage, and to strike the decisive stroke, he suffered defeat.

Similarly, at Austerlitz, the Austrians and the Russians successfully seized a decisive point, threatening the French communications; but, in so doing, they separated their own forces, and succumbed to Napoleon's counterstroke.

Again, in the Battle of Mukden, the Japanese, suddenly developing a powerful attack on the Russian right flank, threatened the Russian communications and line of retreat. They had, undoubtedly, secured possession of a decisive point; for the Russians immediately commenced their retreat. But the Japanese, lacking sufficient cavalry, were unable to press their advantage to the uttermost, or to convert the Russian retreat into a rout.

We thus see that, as fast as superior force has been concentrated at one decisive point, another one crops up. It seems evident that the possession of a decisive point in war, as in the game of chess, merely means that a strong position has been gained from which a powerful attack can, if sufficient force is available, be directed at a vital point of the enemy.

But where then is that vital point? Where is it to be found? Does it exist? It seems evident that it must exist; for otherwise how can we account for the sudden and complete collapse of an armed force, although it has, perhaps, suffered but little loss? Panic, you will at once say. Yes, that may be so; it may be that the vital point has been touched, and panic ensues. But let us then seek to ascertain which is this vital point.

For some centuries in the Middle Ages, after the collapse of the Feudal System, war was carried on in Europe by means of mercenaries. A well-known mercenary leader, having received a commission from some potentate, would raise his standard, and, from all sides, subordinate leaders with their following would flock to it. The object of these mercenary armies was gain and the accumulation of wealth; their last desire was to fight, except, perhaps, against untrained and half-armed men on whom they could, with little or no risk to themselves, wreak their will and satisfy their lust for blood and plunder. These mercenary armies sought to avoid one another as far as possible; but, as the various countries of Europe became devastated and destitute of supplies, the difficulty of doing so increased. Two rival armies would then manœuvre against each other, each displaying its full strength, and growling like two dogs over a bone, in the hope of terrifying its enemy. The weaker usually retired, leaving the

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victor in possession of the coveted territory, and went to seek winter quarters elsewhere.

But with the advent of Gustavus Adolphus all this was changed. He had trained, disciplined, and roused the patriotic and religious enthusiasm of his Swedes. He, himself, was filled with the lust of conquest; and his supremacy over the territories he conquered was obviously incomplete so long as the mercenary armies, maintained by his enemies, were permitted to exist. Placing well-deserved reliance on the martial qualities of his men, he boldly attacked the hostile armies whenever he met them, very often in spite of their superior numbers. The courage and resolution of his men, no less than his own superior leadership, won him the victory. In these wars, the opposing armies fought front to front; there was no question of seizing a decisive point, and thereafter, pressing forward to the attack of a vital point. The vital point lay in the spirit of the hostile forces; that one which could, at the decisive moment when fate hung in the balance, display the finer resolution, which could show the greater "grit," won the victory. At the last great battle of Lützen, when the Swedes, greatly outnumbered, were practically beaten, the death of their King filled them with such fury that they returned to the charge and with one tremendous effort swept their enemies from the field.

Gustavus Adolphus has been called the Father of modern war; and Frederick the Great copied his methods closely. Placing reliance on the training and discipline of his men, that is on their manœuvring and fighting capacity as well as on their resolution and determination to win at all costs, putting faith, moreover, in his own superior generalship, he seldom hesitated, though outnumbered by three to one, to attack his enemy in position and entrenched. He sought out the most vulnerable flank and threw his whole weight against it, confident that his half-trained enemy would be unable to alter his dispositions in the time available. On several occasions he was heavily repulsed; but neither he, nor his army, were ever defeated. At the great battle of Künersdorf, his army was almost annihilated; of the 48,000 men with which he commenced the battle, he was left with but 3,000. For the moment he lost courage at the downfall of all his hopes; it was his misfortune, he said, to be still alive. But there was no pursuit; he quickly regained courage, and re-assembled the remnants of his army. He again showed a bold front to his numerous enemies; fortune turned again in his favour; and, in the end, he not only saved his country, but raised it to the position of one of the great powers of Europe.

In all these battles of Frederick the Great we see the same feature, the sudden seizure of a commanding position, or a decisive point, from which a determined and overwhelming attack was directed against the enemy, the object being no less than the utter annihila-

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tion of the hostile force. There was no locality on the field of battle, however, which can be termed a vital point; that vital point lay in the spirit of the hostile force. From the moment that spirit was broken down, from the moment that the resolution to win was lost, from the moment all ranks recognised that they were outmatched and outwitted and that victory was no longer possible, the army was beaten. At Künersdorf, though the Prussian army was scattered and driven headlong from the field, their spirit was yet unbroken when, on reassembling, they found that their king had not lost confidence. Though numbers of their veterans had been killed, though only 20,000 men had rejoined the colours, and though many of their best leaders had been lost, yet such was the terror of their name that their enemies, though in overwhelming numbers, feared to attack them. But how if there had been a vigorous pursuit?

And now let us turn to Napoleon. His methods were very similar to those of Frederick the Great. He sought, by the direction of his march, to seize at once on a commanding position with concentrated forces. If the hostile army was superior to him in force, he endeavoured, as at Austerlitz or in the Waterloo Campaign, to separate them into two or more fragments; while, if the hostile force was inferior, as at Ulm and Jena, he seized on its lines of communication, interposing between the enemy and his resources and reinforcements. Having gained possession of the decisive points, however, he delayed not a moment, but pressed forward to strike with his whole weight. In this attack he meant to win all or lose all. He employed his reserves to the last man when the decisive moment arrived. "To be repulsed," he says to his feeble brother, Joseph, "when one has 12,000 men in reserve who have not fired a shot, is to put up with an insult." If his attack was successful, he pressed forward in a vigorous and sustained pursuit. He granted his enemy no repose, no time for recuperation. He departed from this principle, doubtless for very good reasons, at Ligny, but he paid the penalty at Waterloo.

There is one noticeable feature which is common to nearly all the great battles of history. When there is no pursuit, the defeated force escapes with a loss but little greater than that of the victor. Very often, indeed, his loss is considerably smaller. A victory is impossible except with a determined attack; and it is generally the assailant who suffers the more heavily during the progress of such an attack. It is only when one force commences to give way, and acknowledges the superiority of the other, that its punishment really commences; and it is only during the pursuit that its losses become terrible in proportion to those of the victor.

It is, clearly, not so much the actual loss sustained which causes an armed force to admit its inferiority; it is the feeling which gradually permeates all ranks that there is no resisting the enemy. The spirit is breaking. But then, it will be said, it is just this loss which causes

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this spirit to break ; an armed force which can inflict losses on its enemy, while sustaining none itself, will retain its spirit unimpaired. This is hardly true. The Boers, as a whole, sought to inflict the utmost possible loss on their enemy ; but the moment it became apparent to them that they themselves must shortly commence to suffer punishment, they thought it high time to be off. It was not in any way due to lack of courage, but rather to a false conception of war. They failed to recognise that great results can only be achieved by running great risks and suffering greatly. At the very outset of the campaign they lacked the military spirit ; and they were, in reality, doomed to ultimate defeat if their opponents possessed the resolution to conquer.

This spirit, which seems to be the vital point of a force, and which, if once broken down, leaves that force helpless, is made up of many component parts. There is, first and foremost, the confidence of the supreme leader in his own powers and in those of his men, his knowledge that he is a master of his art, and that his men know it. There is his determination to win at all costs, a sentiment which rapidly permeates through the subordinate leaders down to the rank and file. It is this spirit of confidence and resolution, which the chief infuses into all ranks, that constitutes that military spirit without which, as Clausewitz tells us, an armed force is worthless.

Let us see on what this spirit of confidence is based.

There are many men with a thorough, though altogether misplaced, confidence in their own powers ; we have, most of us, passed through the phase at one time or another. Such a man, though confident in himself, will not win the confidence of his subordinates. Every capable subordinate will quickly recognise his incapacity. He has built his house on the sand ; and the first heavy blow of misfortune will sweep it away. Of such a type is the 'Heaven-born soldier,' the man who believes that nature has endowed him with such magnificent qualities and such a transcendent brain that he can direct armed forces to victory without ever having given a thought as to how it is to be accomplished and without having studied the methods by which the great masters of war have effected their designs. His confidence is due solely to his ignorance. He believes that the great leaders of history, like himself, were born generals ; he has not read their lives, for he does not believe in reading or in 'bookworms' ; he does not know that the great leaders were one and all, without exception, deep students of the science of war and of human nature before ever they took a weapon in their hands or set an army in battle array. Hannibal and Alexander the Great were both instructed in their boyhood by their fathers, who had given their lives to the study of war and statecraft. Gustavus Adolphus, before ever he came to the throne, had studied the campaigns of Alexander the Great, and this preliminary study is

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manifest in his own campaigns. Frederick the Great was a deep student of the campaigns of Gustavus Adolphus as well as of other great soldiers. Napoleon and Wellington had both closely studied the campaigns of all the great leaders. Moltke, as is well known, was the deepest of students throughout his life.

The man who has failed to study is as helpless in the hands of the trained leader as is the tyro at chess in the hands of the great master. He does not even know why he is beaten, but ascribes it to the faults of his subordinates. He lacks the knowledge to enable him to organise, he criticises in place of assisting his subordinates. He scorns to teach; it is beneath him. He also, usually, lacks the capacity. He speaks scornfully of the teacher. "Oh yes," he will say, "if a man is suited to that kind of work, it is all right." He forgets that every officer in an army must be a teacher, must instruct his subordinates, or be worthless.

It will not for a moment be denied that certain inborn qualities are necessary in a leader of men; but these qualities, and possibly many others with which he was not endowed by nature, must be cultivated if he would hope to lead armed men to victory. He must not be unduly elated by success; he must not be cast down by defeat. He must possess the power to display infinite patience, to check the eagerness of his own spirit no less than to restrain that of his subordinates. But when the time comes, when he has foiled the plans of his adversary, when he has weakened him and placed him in a false position, when he knows intuitively that the moment has arrived at which to strike with his utmost power and force, then he must be foremost in ardent vehemence as formerly he had set an example in patience and endurance. And with it all he must retain complete self-possession.

The great leader leaves no stone unturned to instil his own spirit into the force he wields. He rouses their patriotic or religious enthusiasm. Like Alexander the Great, or Cromwell, or the Maid of Orleans, or the Mahdi, he sometimes claims to be the *protégé* of Heaven; or, like Napoleon, he claims the guidance of his star. While promoting healthy rivalry, he seeks to smother jealousy. *Esprit de corps* is all very well in its way, if combined with the higher and nobler sentiments of *esprit d'armée* and *esprit de patrie* or patriotism. But alone, it develops almost inevitably into petty jealousy. When regiments and corps regard one another with envy and jealousy, the sentiment quickly takes a hold of individuals. Many cases are to be found in history where one man, actuated by petty spite, has refused to move to the assistance of his comrade in difficulties. The jealousies of the French marshals was a principal cause of the defeat of the French in the Peninsula. It was the great fault of Napoleon's system. But his chief consideration would seem to have been his own supremacy; and it is probable that he

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considered it advisable to promote jealousy amongst his marshals as the surest safeguard of that supremacy. Jealousy and spite are, however, quite impossible amongst educated and patriotic soldiers.

The great leader establishes the sternest possible discipline, punishing military crimes, especially those which are calculated to ruin the cause or to sacrifice the lives of comrades, with ruthless severity; for it is only by stern discipline, combined with enthusiasm, that men can be induced to march fearlessly to what appears to be certain death. These were the qualities which, more than all others, pressed the Swedes of Gustavus Adolphus, the Prussians of Frederick the Great, and the Japanese to storm so-called 'impregnable' positions again and again until they had carried them.

The great leader forgives, while explaining the enormity, an error of judgment in a subordinate; for if he punishes such well-intentioned errors he hampers initiative. But he never overlooks carelessness, laziness, or unjustifiable ignorance.

He organises carefully; for he knows that discipline and scientific leadership are impossible without it. But this is not all. Like Nelson he seeks to train his subordinates, to teach them his own methods, to form them into 'a band of brothers.' He knows that those subordinate leaders must be able to command the confidence of their men; and that without their trained co-operation and power of initiative he himself must be quite helpless. More than ever is this the case in modern war, which is an affair of far greater complexity than the war of the middle ages or of antiquity.

These subordinate leaders, in their turn, must train their subordinates; and thus, by degrees, is formed an armed force in which all ranks have implicit confidence in the knowledge and capacity of their superiors, their comrades, and their subordinates. The chief knows that his instructions will be carried out, not in a spirit of pedantic obedience, but with trained intelligence; and that whatever he definitely orders his men to do they will accomplish it or die. The rank and file also know that when they are called on to accomplish an apparently impossible task, that it is not really impossible, but that their chief has adopted measures, of which they know nothing, to second their efforts. They know also that, in any case, their self-sacrifice is demanded of them by every consideration of patriotism, of religion, of duty to their comrades, of discipline, and of tradition—in a word, by the military spirit. They know, moreover, that, if they fail, the enemy will probably get the better of them, and may destroy them all.

If we study the campaigns of the great leaders, we find that, while they fostered the military spirit of their own troops, they struck constantly at that of the enemy. "The great general," writes Colonel Henderson, "whilst raising to the utmost the *moral* of his own men, reckoning up that of the enemy and lowering it in every possible way,

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does not give his first attention to these points, nor to the numbers against him. He looks beyond them, beyond his own troops and across the enemy's lines, until he comes to the quarters occupied by the enemy's leader, and then he puts himself in that leader's place, and with that leader's eyes and mind he looks at the situation; he realises his weaknesses, the points for the security of which he is most apprehensive; he considers what his enemy's action will be if he is attacked here or threatened there; and he sees for himself, looking at things with the enemy's eyes, whether or no apparent risks are not absolutely safe." He strikes, in fact, at what would seem to be the true vital point of an armed force, the mind of the hostile leader. For leadership is an affair of the mind; physique has little or nothing to do with it. It is true that a man who is in physical pain, whose health has given way, can hardly display to the full the qualities of his mind; and, for that reason, it is desirable that the leader should be in vigorous condition both mentally and physically. But we must not forget that the mind can triumph over physical suffering. There is a notable example in history. Torstenson, the Swedish general of the latter end of the Thirty Years' War, was old and worn out, a bedridden paralytic, who was habitually carried in a litter. And yet, he is celebrated for the sudden and fierce energy of his blows and for the rapidity of his marches. He almost invariably surprised his enemy; and, having defeated him, gave him no time for recuperation, but hunted him over half the continent of Europe. It is a point for us to take note of; for we British soldiers are apt to attach an undue importance to physical prowess, and, it seems to me, too little to mental capacity.

The seizure of the enemy's communications before the decisive battle does not really reduce his actual fighting capacity, or lessen his chances of victory—unless, perchance, his reserves of ammunition and food have been captured, and he is forced to fight on short commons. The real blow is directed at the military spirit of the enemy. It is the surprise, which shakes the nerves, tends to destroy discipline and dislocate organisation, that lowers the fighting capacity of a force. It is the threat to the line of retreat which sets every man wondering how he is to escape if defeated. Every educated officer throughout the ranks recognises that his chief has been outmanœuvred, and his confidence in that chief is shaken. The chief, himself, even when he is an adept in his art, feels that he has met an opponent worthy of his steel, and that he must bring into play every artifice of which he is master, that he must concentrate every atom of his intelligence and imagination in the effort to outwit his adversary and turn the tables on him. He knows, and his men know too, that, if defeated in the coming battle, the army will probably be destroyed. But if his self-confidence is misplaced, he then begins to know it, he commences to lose his self-control, he recognises his incapacity, and

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his face shows clearly his perturbation of spirit. His despondency flashes through all ranks of his army.

We read in Napier that, before the battle of Salamanca, Wellington was deeply disturbed by the successful manœuvres of his opponent. Can there be any doubt that his staff, filled with anxiety, scrutinised his face closely while he pondered on the methods by which he might endeavour to extricate his army from its false position? Is there any doubt that the troops nearest at hand scrutinised, and read, the serious faces of the staff officers? Is there any doubt that Marmont had struck a shrewd blow, before ever the battle commenced, at the military spirit of the British army? But when Wellington, seeing the increasing gap between Marmont's main body and his left wing, shut up his telescope with a snap and exclaimed, "Now I have him," can we not imagine the feeling of relief, the restoration of confidence, which flashed through the staff and thence to the troops?

The men who composed the Prussian armies at Jena were not so vastly different to those who had won Frederick the Great's battles against such overpowering odds. It is true that, as General von der Goltz tells us, a 'sickly artistic' conception of war had taken hold of the Prussian nation and leaders; but the training of the rank and file, though by no means so strenuous, was still carried out on the principles of Frederick the Great. The army was full of misplaced confidence. And yet we read in Alison that, before the battle of Jena, "the dejected and disordered columns of the Prussians at length effected their concentration." Up to that time a few detachments only of the Prussians had been overwhelmed; the army as a whole had not been touched. The men had, however, been marched this way and that until it had become apparent to every educated officer, at least, that their chief was unable to face the situation or to fathom the designs of his enemy. We read also that this chief, the Duke of Brunswick, was 'thunderstruck' by the news of the French advance. It is bad when the leader of an army is thunderstruck; it is fatal when he shows it. The troops fought bravely enough; but every man, it is probable, knew that his chief had been outwitted and outmanœuvred, and that he was no match for Napoleon. Every man, it is probable, expected that he must fight against overwhelming odds; he had lost all confidence in his leaders; and it is certainly due to these facts that the bulk of the Prussian army was, at Auerstadt, driven back by half their own numbers of Frenchmen. The misplaced and overweening confidence of the Prussian army had collapsed, giving place to hopeless despondency, the military spirit had been broken, the vital point had been struck, before ever the battle commenced.

But, perhaps, Napoleon at Waterloo gives us a better example than any other of a blow deliberately aimed at the vital point, the military spirit, of the enemy. Napoleon, unaware that the Prussians

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were in full march to the battle-field, delayed his attack in order that the ground might dry sufficiently to enable his artillery to manœuvre —at least, so it has been said. He utilised the time by a pompous display of his army in full view of Wellington's heterogeneous force. He well knew that a considerable part of that force was disaffected, and that other portions were by no means well-trained or well-disciplined. Like Joshua at Jericho, he paraded his tremendous power with banners unfurled and trumpets blowing, in the conviction that the mere display would turn the hostile hearts to water and cause the walls to fall down. And it is probable that he would have succeeded, but for the calm confidence displayed by Wellington and his subordinate leaders, who well knew that Napoleon had been outwitted and that Blucher was marching to their assistance.

Clausewitz tells us that the military spirit thrives on victory ; and that it can only, with the utmost difficulty, be fostered in peace time. The Germans have taken his teaching to heart, as have the Japanese. These nations, recognising that war is the ultimate arbiter in the fate of nations, leave no stone unturned to foster this military spirit in peace time, and to educate the youth of the nation in the sentiments of patriotism and discipline. With us, unfortunately, all classes of society do their utmost to destroy the military spirit, which they regard as 'militarism.' They will, doubtless, in the end, succeed ; but when that happens, there will be no fighting men left in the nation ; and when that occurs, the end of the nation, as history tells us, will not be far off.

The national, or fighting, spirit, as all history shows so clearly, is the vital point of a nation, even as the military spirit is of any armed force. It is made up of exactly the same component parts, patriotism, discipline, organisation, the well-justified confidence of the national leaders in themselves and in the rank and file of the nation, the confidence of the rank and file in the knowledge and capacity of the leaders.

It is only when this national spirit breaks down that a nation admits defeat. In the case of a vigorous nation, its armed forces must be destroyed, its territories invaded and occupied, its resources seized, its liberties suppressed, before it can be brought to recognise the hopelessness of further opposition. And, even then, like Frederick the Great's army after Künersdorf, it is unbeaten. But the self-satisfied and complacent nation, full of unwarranted confidence, collapses, like the Prussian nation after Jena, at the first sudden and unforeseen stroke ; the awful shock is too much for its flabby nerves ; like a flash the conviction comes home to every man, when it is too late, that the nation is no match for its enemy, that it has been hopelessly outwitted, outmanœuvred, and outfought. The nation recognises, at last, the appalling fact of its inefficiency, and succumbs without further effort. Overweening confidence falls at

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the first blow to hopeless despondency. The national spirit is broken, the nerve centre has been pierced, and the nation lies paralysed beneath the heel of the conqueror.

In the late war, the Japanese sought not only to destroy the Russian navies and armies; every blow would seem to have been directed at, and calculated with regard to its effect on, the national leaders in Russia. If the incapacity of these could be exposed, and if they could be brought into disrepute, internal trouble must result, and the strength of the nation must diminish. And more than that, strained relations between the people and the leaders in Russia must react on the leadership of the Russian armed forces in the theatre of hostilities, demoralising both officers and men, and opening up opportunities to the Japanese. If a nation in arms attacks Great Britain, every blow it strikes will be directed at the nerves of our untrained national leaders, and calculated with regard to its effect on the vast and undisciplined masses of the unemployed, the unemployable, and those on the verge of starvation.

But we cannot bring ourselves to believe that an enemy could be so unscrupulous as to strike at our weak points, to strike suddenly and unexpectedly. We do not, therefore, seek to rectify our weaknesses. As with the Prussians before Jena, so with us, a sickly artistic or sickly sentimental conception of war, of life, and of human nature, has taken a hold of us all. The pen, they say, is mightier than the sword, the babbling orator of more value than the trained and educated fighting man. It is a fallacy; but the fallacy is only made manifest when the sword flashes from the scabbard.

A comparison between the British nation of to-day and the Prussians in 1806 is hardly calculated to increase our misplaced confidence. Such a comparison has been ably drawn by the military correspondent of "The Times" in his *Imperial Strategy, 1806 and 1906 —a Parallel.* Our countrymen of to-day are filled with a misplaced confidence, which is, I fear, fated to give way to hopeless despondency at the first shock of a serious war. Let us endeavour to break down this false spirit while there is yet time, and to replace it by the true spirit, based on a resolute determination to win at all costs, on a scientific knowledge of what we shall have to do and of the methods by which we intend to do it.

And now, I will venture to give a word of advice to the young officers who are present here. It is this. There may be some amongst you who have been endowed by nature with the great qualities requisite in a leader of men. No man of you can tell whether or no he possesses these qualities until he is put to the proof. But these qualities will be quite useless to you, to your comrades, and to your country, unless you cultivate them, unless you can gain the power to exercise a rigorous self-restraint, unless you possess not only a capacity but even a liking for hard work. And even then, they

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will be valueless unless you superimpose upon them a profound knowledge of the science of war and of human nature, which can only be obtained by constant study.

There are very few fighting men in this old country of ours; and it is improbable, unless conditions are materially altered, that we shall be able to withstand the onset of a nation in arms. But if you, the rising generation of British soldiers, can be induced to dedicate your lives to your country, to give every ounce of your capacity and energy to the study of the science of war and to the means by which nations triumph over their enemies, you may, when the time comes, do great things for your country, you may, even yet, save it.

It is no light task you have undertaken, and the time is short in which to prepare yourselves for the vast responsibilities which will assuredly devolve on your shoulders. It may even be that you will be called on to goad your countrymen into action, to force them, against their will, to fight it out to the bitter end, as the only means by which you may hope to save them from destruction. If that time comes, as come it probably will, let us hope that you will act your part bravely and fearlessly, with never a thought for your own interests, as becomes devoted and scientific British soldiers. If, on the other hand, you slack now, if you cannot spare time from your amusements for hard work, why then Heaven help your country. But Heaven will not help it; Heaven has never yet, in the whole course of history, assisted a flabby nation.

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TRANSCRIPT.

FIELD FORTIFICATION AFTER THE WAR IN SOUTH AFRICA AND THE RUSSO-JAPANESE WAR.*

The Effect of Modern Firearms on Field Fortification.

Since the introduction of breech loaders in the latter part of the 19th century there has been an epoch of constant improvement in firearms. The end is not yet in sight and the march of progress is constantly increasing in rate.

The experiences of the last important European Wars, in which the combatants were armed in very dissimilar manner, have only served to increase the keen rivalry on the question of armament.

The improvement in armament during the last decade or so has been exceptionally rapid, particularly as regards the rifle, which now, by its hail of bullets, more than ever decides the fortune of the day. Machine guns and Q.F. guns have also improved out of all knowledge. In fact the recent increase in efficiency of armament has not been equalled in any other period of equal duration.

Thus, although the introduction of breech loaders was a most conspicuous event in the history of armaments, it did not of itself give to the individual weapon that marked superiority over its predecessor which characterised the introduction of magazine or repeating mechanism.

It must further be remembered that the increase in efficiency of fire-arms must not be judged by their actual comparative effect in war. The number of killed and wounded does not vary directly with the destructive capabilities of the weapons used. In many battles during the last half century the casualties amounted to only 10, 5, and even 2 per cent. of the combatants, and in South Africa especially the casualties were exceptionally low.

As a rule it may be said that improvements in firearms produce an increased discretion in exposing troops to their fire. Civilisation has also had a baneful effect on the fighting powers of armies, and modern wars will usually be decided without very severe losses. In this respect the high percentage of killed and wounded in the Russo-Japanese war speaks strongly for the obstinacy of the struggle and the exceptional bravery of the combatants on both sides.

* From an article by Capt. Vinzenz Reimer, No. 15 Pioneer Battalion, in the February, 1907, number of the *Mitteilungen über Gegenstande des Artillerie-und Geniewesens.*

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Taking a general view of the recent improvements in artillery and rifle armament, the following appear to be the most important results :—

(1). The rapidity of fire, both with rifles and field guns, has been enormously increased.

(2). The dangerous zone has grown very considerable owing to the increased range.

(3). The accuracy and effect of single shots has developed very conspicuously.

The effect of these improvements on the tactics of field warfare, and especially on Field Fortification, must be very great.

The Importance of Cover against Modern Weapons.

In the most recent wars, namely those in South Africa and in Manchuria, one of the most noticeable features was the continual and elaborate use of artificial cover.

The Boers, as is well known, entrenched themselves on every occasion. The English, who were bent on offensive tactics, were yet obliged to make frequent use of trenches and sangars; and it must be noticed particularly that they entrenched themselves not only when they were compelled after an unsuccessful attack to adopt defensive measures, but also in the attacks on the Tugela and Spion Kop and after occupying Vaal Krantz and during the final struggles which resulted in the relief of Ladysmith.

As regards the Russians they almost always fought from behind cover; and even when they purposed to make a vigorous attack, as in October, 1904, against the Japanese position Bensiku-Jantai, it generally ended in their entrenching themselves in the ground they won.

The Japanese made a most extensive and careful use of entrenchments. Not only did they strengthen their positions by these means, and dig trenches during cessations of hostilities, but their infantry used to regularly dig themselves cover whilst actually under fire and during their attack. If the ground was too frozen to dig sandbags were used, and the men of their own accord, without receiving any order to that effect, would carry sandbags with them when ordered to attack.

It will thus be seen that during the latest wars, under different conditions and in different parts of the world, all the combatants have made the utmost use of artificial cover. Can this be explained by any well-known partiality for fortification and defensive tactics on the part of the particular countries engaged?

In the case of the Russians it may be so. They certainly spent much time and labour upon earthworks, which in many cases were not wanted; and they would sometimes have done better by advancing instead of entrenching themselves. For example the Russian forces in the Kwantung Peninsula in June, 1904, would have achieved far greater results had they advanced against the 3rd Japanese Army, which at the time did not amount to 2 divisions, instead of taking up and fortifying an extensive position, thus giving the Japanese time and opportunity to reinforce their

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troops. It is difficult also to see what advantage the defence gained from many of the works constructed at Liaoyang, on the Shaho, and at Mukden.

In the armies of other nations, however, we do not find any such marked preference for defence works.

The Boers at the beginning of the South African campaign undoubtedly took the offensive, though it was marked by excessive prudence. Moreover, had they made early use of entrenchments it would be easily explicable. But, being undisciplined troops, and largely composed of men unaccustomed to hard manual labour, they undoubtedly shirked the work of digging trenches or putting up sangars.

The English, on the other hand, could not bring themselves to believe that they would ever need to take refuge behind field defences. Consequently the two forces at Ladysmith stood opposite each other for several weeks without resorting to spade work at all. It was not till after the fight on the 30th October, 1899, that defensive works were begun by the besieged. General Buller's force too left their infantry entrenching tools behind, but soon regretted it, and had to do the best they could with the tools that were left them. (The above remarks seem to have been copied from some German official publication.—C.O.P.).

It is thus apparent that the appreciation of the value of field defences cannot be accounted for by any initial prejudice in their favour on the part of any of the combatants in recent campaigns. On the contrary all the participants started with ideas of purely offensive tactics and only adopted artificial cover because experience proved its value.

Neither can an explanation be found in the peculiar nature of the ground, as field defences were resorted to finally under every condition, in the plains and on the mountains, in sandy soil or amidst rock and scrub.

No, the cause of the increased value of field defences lies in the fact that the tactics adopted in the days prior to the introduction of the magazine rifle and Q.F. artillery are to-day foredoomed to failure. In particular the rapid and exposed advance against a defensive position, which was formerly considered the correct method of attack, is now recognised as involving enormous loss whilst promising very small prospect of ultimate success.

The English at the beginning of the South African war advanced against the Boer positions in their accustomed formation and paid dearly for it, *e.g.* on the Tugela and at Modder River and Magersfontein. Not being so tenacious as the Japanese they generally retired, and were slow to adopt new tactics; a flank attack often offered no better prospect as it only brought them up against an equally strong position. Fortunately the Boers did not make the best use of their initial advantages and the English soon learnt to make use of all available cover. The infantry attack now lasted for weeks instead of hours, and in the constant use of artificial cover began to resemble siege warfare.

The Japanese at the beginning of the Eastern campaign were more successful with their forced attacks, but solely owing to the obsolete methods of defence adopted by the Russians; and when the latter had

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learnt their lesson and improved their defensive measures, the Japanese were compelled to make constant use of artificial cover in their attacks.

From the experiences in these recent campaigns one may therefore draw the following conclusions with regard to the use of cover.

In view of the efficiency of modern weapons it is no longer possible in a direct attack on a capable defender to attempt an open and uncovered advance.

The concentrated fire obtainable from magazine rifles and the rapidity of fire of modern artillery compel the attacking side as well as the defence to make the most careful use of cover, both natural and artificial.

Natural cover is seldom available. Therefore artificial cover has generally to be resorted to, and this is the real explanation of the extended use of field works in recent campaigns.

DESIGN OF ARTIFICIAL COVER.

VALUE OF INVISIBILITY.

In considering the principles for the siting and design of field works, it will be advantageous to turn again to the lessons learnt in the recent campaigns.

At the beginning of the Boer War it seemed that bombardment of the hostile positions was of no effect; the Boers suffered no loss and were not demoralised. Before General Buller's first attempt to relieve Ladysmith the Boer position at Colenso was bombarded by naval guns for three days; and the English were able to aim and observe without hindrance, as no answer was made to the bombardment. Yet the infantry attack was routed. The reason is to be found in the fact that the Boer trenches were so cleverly concealed that they had not suffered at all.

The same thing occurred at Modder River and many other engagements; and though it may not be possible in European campaigns to conceal the defences so thoroughly, yet the experiences in South Africa prove undisputably the very great value of concealment.

The Russians were not nearly so skillful as the Boers in concealing their works, which usually consisted in the early period of the war of huge earth parapets on most conspicuous positions.

At the Yalu, in spite of strong breastworks (see *Fig.* 1), their artillery fire was silenced by the Japanese guns after 25 minutes; at midday on the same day they re-opened again, but after an hour had to vacate their position.

The Russian infantry trenches (*Fig.* 2) in the early part of the campaign were much too conspicuous, though the interior arrangements were good. The parapet was wide and very high and no attempt was made to conceal it, and the sites selected were too conspicuous. Thus in almost every case they offered an easy target to the Japanese artillery. The rapid success of the Japanese attack on the Yalu was largely due to the effective artillery fire they brought to bear on the trenches.

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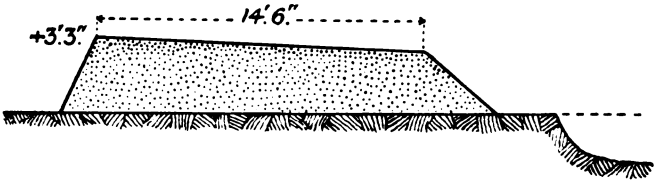

Fig. 1. Russian breastwork for artillery ($\frac{1}{100}$).

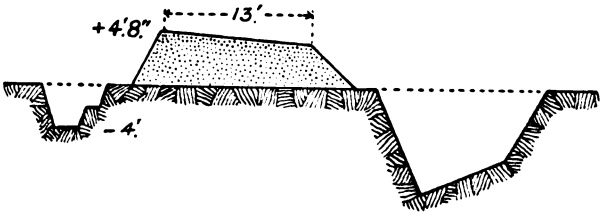

Fig. 2. Russian infantry trench ($\frac{1}{200}$)

The Japanese, on the other hand, appear to have recognised from the outset the great value of invisibility and concealment (*Figs.* 3 and 4). Their artillery in attack and defence was usually behind cover, and was better protected in their temporary works than the Russian artillery in permanent ones.

Figs. 3 & 4. Japanese infantry trenches ($\frac{1}{100}$).

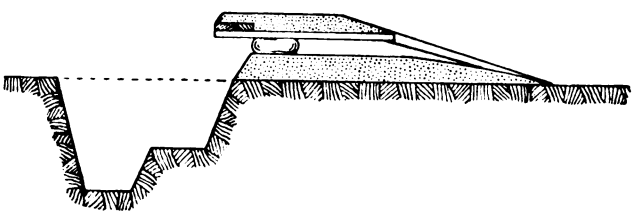

Fig. 5. Russian trench with overhead cover ($\frac{1}{100}$).

The reasons for the value of concealment are easy to understand. The great distances at which battles of to-day are begun, and in many cases decided—a result of the increased range of all weapons—make the task of discerning the enemy's position and movements very difficult.

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But while distances have increased the range of the human eye remains stationary. Telescopes and field glasses are limited both in number and power, and do not therefore overcome the difficulty, while the introduction of smokeless powder makes the location of hostile troops harder than ever.

It would therefore be a foolish policy to decrease the difficulties experienced by the enemy in locating his target by adopting a conspicuous type of trench. Moreover it must be borne in mind that field defences cannot be made proof against heavy artillery fire, and therefore their chief protection against this form of fire lies in their invisibility. Well-concealed positions have, too, another, and perhaps more important, advantage than that of eluding fire, namely, that they often cause the enemy to adopt an erroneous line of action which may even directly lead to his defeat.

FORM OF COVER IN DEFENCE.

(*a*). *Infantry Cover.*

The South African campaign offers some good examples of infantry trenches.

The Boer position at Paardeberg was shelled for 10 days by some 90 guns. The defended area, which measured some 2,200 by 1,100 yards, could be thoroughly observed from the English balloons; and more unfavourable conditions for the defence are hardly imaginable. Yet the Boer losses were only 250 out of 4,000 men.

Their trenches were deep and narrow; they could not be touched by direct fire, and only offered a very small target to high angle fire. The sides of the trench were undercut at the bottom in order to offer additional protection.

Both the Russians and Japanese adopted deep and narrow trenches. The latter, indeed, from the beginning of the campaign avoided high relief works. The Russians, however, required experience to teach them.

To further protect the men in the trenches from shrapnel fire the Russians added overhead cover (*Fig.* 5).

Where possible the whole trench may be roofed in with planks, sleepers, doors, etc., and earth laid over all (as in *Fig.* 6), the occupants firing through loopholes. The Russians used trenches of this type in the defence of Port Arthur with the best results. The advanced redoubts were not taken till 20th September, 1904, *i.e.* 51 days after the investment was completed, and then only after very severe fighting.

An entirely covered-in trench of this type gives protection both from weather and shrapnel fire; and forms a substitute for the ordinary overhead cover or for the type with undercut cover for the garrison when not firing (*Fig.* 7).

The removable shield shown in *Fig.* 8 was only a precursor to the completely covered-in trench.

It is obvious that a completely covered-in trench requires no traverses against enfilade rifle fire, and all that is necessary is to build an occasional traverse to localise the effect of a shell falling in the trench.

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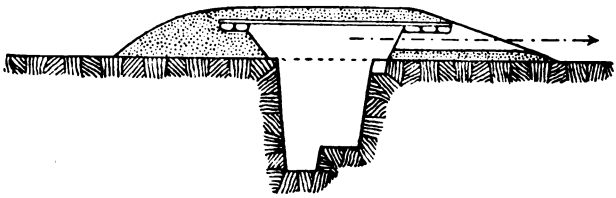

Fig. 6. Completely covered trench ($\frac{1}{100}$).

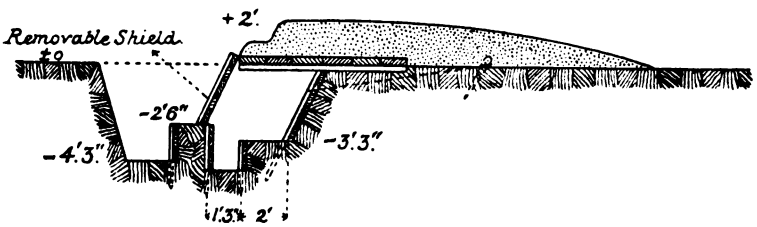

Fig. 7. Trench with undercut cover ($\frac{1}{100}$).

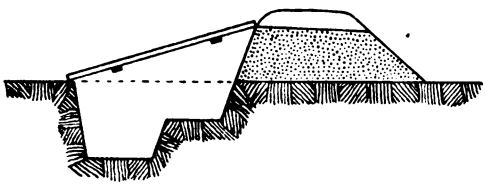

Fig. 8. Trench with removable shield ($\frac{1}{100}$).

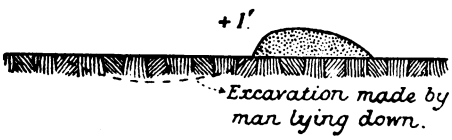

Fig. 9. Japanese trench for prone position ($\frac{1}{100}$).

(*b*). *Artillery Cover.*

Artificial cover for guns did not play so important a part in the two campaigns as infantry cover. As already stated, it was soon found that greater security was obtainable by eluding the observation of the enemy than by erecting a strong work.

Trenches for the detachment were however invaluable. The introduction of shields on the guns does not alter the conditions much, as they are useless against common or high-explosive shell and also only protect a small proportion of the detachment.

In very open and exposed positions, however, the guns themselves must be protected.

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(*c*). *Cover for Reserves, etc.*

Cover for those reserves which are sent up to the close vicinity of the firing line will be constructed on the same principle as the firing trenches, that is they will be well concealed, with very low command, and will be provided with splinter proof overhead cover.

If time admits, and the position is a very important one, bombproof cover might be provided.

Where cover for reserves who are not in the neighbourhood of the firing line is provided, such cover must be so sited and arranged as to be completely hidden from view of the enemy and protected from shell fire.

(*d*). *Infantry Cover in the Attack.*

In both campaigns it was found that, in spite of the great improvement in artillery, the weapon that finally decided the day was the rifle.

The percentage of loss from artillery and rifle fire respectively proves this conclusively. In the South African war the losses were almost entirely caused by rifle fire. In the Far Eastern campaign the small proportion of casualties due to artillery fire aroused general amazement; perhaps, however, without adequate reason, since the moral effect of artillery fire should not be overlooked, although it does nothing to increase the casualty list. Even in Port Arthur, where the artillery played a most important *rôle*, the Japanese losses by artillery fire were only 21% compared to 73% caused by rifle fire.

It is undoubtedly due to the fire effect of the modern rifle that the attacking side has to advance with so much caution, and that the defensive has been able to hold its own so well against attack.

The Boers, after one or two unpleasant experiences, entirely gave up all attempts at direct attack; and the English learnt to make great use of night work and artificial cover in attack.

The Japanese, taught by the losses sustained in their attacks, have combined artificial cover into their methods of attack and reduced the whole to an exact system. If it is impossible to surprise a position, the skirmishers advance under cover of night to the first position selected for the firing line, and here entrench themselves. The further advance takes place by short rushes, the positions gained being immediately entrenched.

The trench is at first only for firing from a prone position (*Fig.* 9). It is at first only a protection from rifle fire, but is afterwards provided with a deep trench to offer cover from artillery.

The methods of the Japanese advance will probably be imitated in the future against any worthy and vigorous opponent, and also their organisation of cover in attack. The most important perhaps is the cover against rifle fire. This cover will be of the type shown in *Fig.* 9, and when possible will be deepened afterwards to provide protection from shrapnel fire; but the parapet must always be kept as low as possible.

OBSTACLES.

In the campaigns under consideration attempts at surprise and night attacks played an important part. The Japanese generally waited till nightfall before advancing to the attack.

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The value of obstacles has increased owing to the frequency of night attacks. In front of Port Arthur many such attacks were frustrated by the obstacles alone. The extent to which the Japanese troops were checked by the Russian wire entanglements is shown to a certain extent by the fact that every infantry company had to be supplied with 30 wire cutters.

Barbed wire is the best obstacle, because it is little damaged by fire; the next best is abatis.

The obstacles should not be placed more than 120 yards from the work; because, if they are beyond easy hearing distance, they may be removed at night with comparative impunity.

Where possible obstacles should be concealed from view. If time is available they may be placed in a sunken way, so that they may form an unexpected hindrance to the attack. At the same time, in order to prevent its being cut by a man lying down beside it, every entanglement should be completely exposed to the fire of the work it protects.

Mines occupy a special position amongst obstacles. How great a moral impression they create may be incidentally gathered from the accounts of newspaper correspondents in the Far East, who more than once reported that battalions and even entire regiments had been annihilated by the explosion of a mine. It is a fact that such bodies were brought to a standstill and sometimes put to rout by these means; but not more than this.

The Russians made constant use of mines; but automatic mines were rare, the majority being fired electrically from the work. Most of them failed owing to the leads being severed by bullets.

In the future, therefore, it is unlikely that mines will be used directly in front of works, as was the Russian practice, because they are so likely to be rendered ineffective by hostile fire. But automatic mines, placed in hidden positions and consisting of small charges only, would be very useful to check and retard the advance of the attackers, and to act as vedettes in places concealed from the defenders, in defiles, etc., where their explosion would denote the presence of the enemy.

ADVANCED POSITIONS.

The two campaigns under review have clearly shown that the modern rifle enables the defence to keep the attackers at a greater distance than formerly and yet inflict heavier losses on them; and owing to the greater distance the time during which the attacking side is exposed to the fire of the defence has also increased.

The advance of the attacking side to decisive range has therefore become harder and slower; and even when this point is reached the enormous power of the rifle fire of the defence forms an almost insuperable obstacle to a speedy conclusion. In the Far East it often happened that the opponents were so close that they could throw hand grenades into each other's works, and yet they dared not leave their trenches for the final assault.

The long duration of battles in South Africa and the Far East was so universal that where exceptions occurred they can be traced to specific causes, such as the speedy retreat of the attacking side or an obvious want of precaution on the part of the defence.

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Nearly all of the decisive battles were of long duration. Buller's second attempt to relieve Ladysmith lasted 9 days and was indecisive; his last attempt took 10 days to accomplish, although he outnumbered the Boers by 6 to 1; altogether the opponents remained opposite each other on the Tugela for 3 months. The investment of Cronje at Paardeberg lasted 10 days. In the sieges of Mafeking, Kimberley, and Ladysmith the English were able to maintain themselves behind most simple fieldworks for months together. It is doubtful if they would have done so had not the Boers been inspired with such respect for the modern rifle.

These periods were repeated in the Russo-Japanese War.

As the duration of fighting increases with it increases also the value of field defences, by the use of which alone a force can maintain itself for such long periods exposed to the fire of modern weapons.

But however valuable cover is to a force, the decisive factor remains always its own fire. Field Fortification therefore must above all things help to develop and increase the fire effect of the force that employs it.

The question of advanced positions must also be considered, their purpose being either to deceive the enemy or to gain time.

They were not very conspicuous in the Russo-Japanese war, though the Russians (with the French and Italians) are strong supporters of them. As a rule their advanced posts were easily captured by the Japanese, and such rapid success raised the spirit of the attacking side and depressed the defenders; even the valiant defence of Kinchau, which only ended with the annihilation of the Russian garrison, appears to have had no other effect.

It is very difficult to convince the public generally that an enforced retreat at one point may be accompanied by success at another; and when advanced posts are captured, as they probably are bound to be sooner or later, a depressing effect is produced on the whole force and also the public.

So also there are weighty objections against fortifications being laid out in rows one behind the other. The large amount of cover required involves a great deal of work, restricts supervision, and attracts the attention of the hostile artillery. False trenches would indeed be preferable.

Many of the laboriously constructed Russian positions were given up before they were attacked at all; but even when seriously attacked, they had no particular value. The most that can be said is that some of the positions in rear held out for a short time, but never to such an extent as to effect the result of the conflict; with the fall of the first or main line of defence the result was decided. The Boers in their single line of trenches held out most successfully; whilst in the defence of the Nanshan position the multiple lines of defence were of no avail.

The chief objection however against multiple lines is that the laborious work involved only has the effect of tying down a number of men to an unimportant place and robbing the actual firing line of their presence; and if reserves are placed therein they get a false idea of their proper *rôle* and remain chained to the spot instead of being essentially a mobile force.

The Japanese saw the weakness of the Russian multiple lines and quickly took advantage of it. Even the Russian engineer officers learnt to condemn them, one Russian colonel saying "The multiplication of lines

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of defence constitutes a weakness rather than strength, as the complicated works and obstacles in front relieves the attacker of all fear of a counter-attack."

Whenever the defence aims at obtaining a decisive victory one line of defence must suffice, in order that there may be at disposal a large mobile force; for in these days of outflanking movements a strong mobile reserve offers the best, if not the only, chance of ultimate success.

LAYING OUT POSITIONS.

The experience gained in these recent campaigns shows that, in spite of the improvements in firearms and the increased power of resistance they confer on the defence, no success can be obtained by a purely passive defence.

The Boers, soon after the campaign had begun, adopted an attitude of passive defence, which entirely robbed them of the fruits of their initial successes. Three times on the Tugela they repulsed the attack of the English relieving army, but never followed up their advantage. Thus they gave the enemy time to recover, and were themselves eventually forced to yield. During the seven days conflict on the north bank of the Tugela, the English were frequently repulsed and entire brigades retired in disorder, but the Boers were quite content with their momentary success and indeed granted an armistice. At other points of the line the English had gained possession of some of the works; instead of collecting all available forces to drive them out, the Boers allowed them, on account of the armistice, undisturbed possession of the heights they had won, and gave them every opportunity of preparing for further attacks. The only time the Boers attempted a vigorous counter-attack was at Spion Kop, where the English by a night attack had gained an important height in the Boer position; the Boers attacked them on all sides, and not only turned them out but induced the English general to give up his attempt.

In the Russo-Japanese war the passive attitude of the Russians was often the cause of their misfortunes. On the other hand the Japanese were exceptionally vigorous in defence. In the fight at Wafangku the Russians made a strong attack on the 3rd Japanese Division, which was entrenched; and the 2nd Brigade of the 35th Russian Division threatened to outflank the Japanese position. The Japanese at once sent out a cavalry brigade, which attacked and repulsed the Russian force.

Success can only attend a policy of activity and initiative, and the defence must have at disposal mobile forces not tied in any way to any particular position.

One of the most important lessons in fortification is to economise the force actually in the firing trenches in favour of a mobile reserve. The increased efficiency in firearms permits of greater economy in this direction than was formerly possible, as the front need not be so thickly occupied, and intervals are less a source of weakness than they used to be. *Points d'appui* must however be held in strength, and such points will be rare and only on the most important positions.

Another point of great importance must be considered when selecting a defensive position. Frontal attacks are now very serious undertakings,

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therefore the value of investment or outflanking has increased, and this must be carefully taken into account.

The flanks of a position now require increased attention. They must not only be well situated, but they must have an excellent field of fire, and wire entanglement or other obstacles should be erected round them in well-concealed positions. But the best way of securing the flanks of a position is by taking an active offensive at these points; if this is contemplated, great attention must be paid to the communications between the flanks and the position of the main reserve.

Siege or Open Warfare.

The student of the South African and Russo-Japanese wars cannot but ask himself whether Europe also is confronted with an era of siege warfare.

As far as the weapons now in use are concerned the answer must be in the affirmative, as modern firearms have so strengthened the resisting power of a well-entrenched force that a vigorous defensive policy holds out great prospects of success.

The excellent quality of the roads and communications in Europe lend themselves naturally to outflanking and investing movements, and such movements tend to the type of position warfare which formed the main feature in the two latest campaigns.

There is however a more important factor than the modern firearm to be considered in this connection and that is the quality of the personnel. It is more than doubtful whether the armies of European states will be able to withstand, as well as did the Boers, the Russians, and the Japanese, the nervous strain caused by the unceasing hail of bullets and shells from modern ordnance.

Frequent instances were reported from Manchuria of Russian soldiers going mad under the strain, and Russians are heroically brave in passive endurance. The Japanese also on occasions refused to obey the command to advance against the murderous Russian fire at Port Arthur. We cannot hope that European endurance will surpass that of Russians or Japanese.

In conclusion one more point which has some bearing on Field Fortification may be considered with regard to these two recent campaigns. Victory in each case lay with the side that displayed the greater energy.

British determination, in spite of mistakes and distances, ended in victory over a patriotic people who were at the beginning of the campaign better armed, more numerous, and thoroughly acquainted with the theatre of operations. The Japanese won in spite of the enormous strength of their rivals. But both Russians and Boers were lacking in energy or history might tell a different tale.

It is energy that will in the end always decide the fate of campaigns; and in considering the Field Fortification of the future we must bear in mind that all schemes for the shelter and defence of troops must be subordinated to the dispositions for adopting a vigorous offensive when opportunity offers.

C. Otley Place.

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NOTICES OF MAGAZINES.

Engineering Record.

March 9th, 1907.

Classification of Excavation and Embankment.—In America many controversies have arisen from time to time over prices to be paid to contractors for excavation and embankment work, mainly in connection with railway construction. In calling for tenders it is now commonly the practice to give only the number of cubic yards of excavation or embankment, leaving it to the contractor to make a price which shall cover all kinds of material taking the easy with the difficult. This is probably less advantageous than arranging different prices for the different classes of work in the way to which we are accustomed.

Certain companies do indeed classify to the extent of dividing into the categories of "earth, loose rock, and solid rock." But there are difficulties in defining the line of demarcation between these materials; for example, a common specification is "Rocky material which can be removed without blasting is loose rock, and that which cannot is solid rock." It is just the words *can* and *cannot* which prove stumbling blocks. In practice, says the author, it is nearly always cheaper to blast so-called loose rock than to pick or bar it apart; and again undeniably solid rock can be disintegrated by slow degrees without blasting (one can imagine the expert witness getting in some fine work here). Some solid material might be dug slowly by a steam shovel without blasting.

On the whole he thinks that the only satisfactory method of definition is the laying down of certain physical uniform tests, and the following are suggested:—

Earth.—Material which in its customary natural state can be ploughed, *i.e.* could be ploughed cutting a furrow 10″ wide and 10″ deep, the plough being drawn by a team of four horses or mules at reasonable ploughing speed.

Loose Rock.—Earthy or mixed material, not susceptible of ploughing as above, capable of being picked apart by two men serving, one man shovelling or loading by hand: solid rock in separate masses exceeding 1 cub. ft. each and not exceeding ½ yd. cube: use of explosives not barred.

Solid Rock.—Rocky material in masses, exceeding ½ cub. yd., which cannot be picked apart or displaced without explosives and cannot be barred apart by men working as above.

It is to be remarked that this classification does not provide any distinction between the very varying degrees of hardness of solid rock. The amount of time needed for preparing blast holes and the actual amount of blasting required to shatter or loosen the rock sufficiently to admit of its removal vary immensely with its quality.

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The author also comments on the old practice of specifying that embankments "must be carried up in layers of two feet thick"—a practice commonly more honoured in the breach than in the observance.

Again, contracts commonly specify against subletting. He remarks rather pertinently "the sub-contractor exists because his services in detail as foreman, manager, or contractor, combined with his financial interest in results and his special plant, at times conduce to more efficiency than could be obtained in any other way."

April 6th, 1907.

INSTRUCTIONS FOR REINFORCED CONCRETE FIELD WORK.—The following hints are worth extracting :—

Casing.—All joints must be fairly tight, so as to prevent leakage of the liquid mass and consequent honeycombing in the concrete.

In making casings and centrings remember that the cost of timber is a large item of the total cost. With a little ingenuity and forethought repeated use can be made of each piece of timber.

Reinforcing Steel.—The steel as received should be checked, assorted, and stored. Steel should be free from loose scale, but a thin film of rust is not objectionable. Oil or paint coating is objectionable. Bars should be cleaned, if necessary, with wire brushes.

Placing Concrete.—Casings must be clean and free from shavings or foreign matter before the concrete is placed. The concreting ought to be carried on continuously. If it is necessary to cease placing the concrete, *e.g.* at end of day's work, the cessation in beams or girders should take place at the centre of the beam in a vertical plane or else over the centre of a supporting column, in the latter case making a vertical joint and allowing half the column to become a bearing for the adjoining beam. In slabs break the concrete over the centre of the beam.

Beams and slabs should be filled to their top surface at one continuous operation.

In building columns, the column box should be inspected by looking through from the bottom before commencing filling. In filling it is essential that air bubbles be expelled by puddling or joggling the concrete with a wedge-shaped rod.

Concrete must not be disturbed or walked over after it has begun to set.

The date of execution of each of the concrete portions of a work should be marked on the plans; and it is advantageous, for purpose of future reference, to make up a sample block, 6″ × 6″ × 6″, of the concrete used each day.

Removing Casing.—Before removing any casing the superintendent should personally satisfy himself of the condition of the concrete. It should not only show sufficient hardness but should ring when struck with a hammer.

At the end of not less than two weeks the posts supporting floor slabs may be loosened and lowered a couple of inches, being so left 24 hours while the slabs are inspected; the bottoms of the beams and girders

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should be left supported at first. Immediately after the original casing is removed the floor slabs should be temporarily shored and so left for at least a week. Shores should not be removed from under sides of beams for at least three weeks.

April 20th, 1907.

MEADOW ROADS IN CAPE MAY COUNTY, N.J.—The construction adopted for roads across the marshland to the various seaside resorts on the coast is not without interest. The marshlands consist of deposits of soft mud, frequently as much as 25 ft. deep, overlaid by a sod or crust of sedge or grass roots. In many places this sod is not strong enough to support a horse.

The system of construction adopted is as follows :—A foundation is laid of poles and stringers (*i.e.* apparently a sort of mattress) of sufficient area to support the weight of the soil filling and the "pavement," together with the stresses caused by traffic, without breaking down the meadow crust. The sides are protected from wash by curbing and bulkheading throughout the entire length on both sides of the roadway, besides a continuous line of mudbanks compacted along the outer side of the curbing. In more recent construction "ties" have been put in every 3 ft. of length under the pole foundations and spiked or bolted to the piling supporting the side curbing or bulkheading.

The formation is made up with upland soil and finished with a surface of shells and gravel to a height of 2 ft. above mean high-water line. The "paving" found most suitable so far consists of 5 in. thickness of oyster shells covered with 4 in. of gravel, and this has been found to stand the wash of storm tides well.

C. E. VICKERS.

JOURNAL OF THE ROYAL ARTILLERY.

May, 1907.

SIEGE ARTILLERY LESSONS FROM PORT ARTHUR, by Colonel E. G. Nicholls, R.G.A., gives a brief narrative of the events of the Siege, including a discussion of the reasons which first led the Japanese to attempt a capture of the Fortress by a *coup de main* and which, when regular Siege operations became necessary, led them to attack the eastern instead of the western section.

As regards the latter point the author says that, in selecting the point for the attack, the only general rule which can be laid down is that the choice should be made so as to reduce the place in the least possible time and with the least possible labour and loss. It is therefore generally desirable to attack either

(1) The weakest side, *i.e.*, the one likely to offer the least resistance,
or (2) The side which, from its inherent importance, will, if captured, lead to the surrender of the place.

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At Port Arthur the western side, including 203-Mètre Hill, fulfilled both these conditions.

Colonel Nicholls enters into a valuable criticism of the Siege, more especially from the purely artillery aspect. With reference to the Engineer operations he considers that the Japanese sappers acquired their knowledge of siege work from experience gained in the Siege itself and had not been specially trained in this particular branch of their duties. There was a lack of method and science, and the absence of a capable guiding hand. Consequently the Japanese, in their eagerness and impatience, were always a stage in advance of the engineer. Thus

(i.). In August the assault was made before any ground had been broken.

(ii.). In October the forts were stormed before the engineers had got into the ditch.

(iii.). In November storming was again attempted before the engineers had got over the ditch and could arrange to blow up the escarp.

This want of high direction only led to a terrible waste of human life. In the end the fortress was not captured until the engineer works had been completed.

On the Russian side the vigour and determination of the defence seems to have been due to the personal supervision of General Kondratenko, and it was not until his death on 16th December that the Russians began to show signs of wavering. The engineer works were skilfully planned and executed, but the artillery positions were badly chosen. The experience of the Siege seems to prove that forts are no places for guns, and that the only weapons in forts should be machine or light Q.F. guns to repel assaults.

Attention is called to the employment by both sides of the old hand grenade and to the use of small bomb-throwing mortars. The grenade has probably returned to stay; for the deep, blinded, and traversed type of trench rendered necessary by modern gun and rifle fire prevents the effective use by the assailant of either bullet or bayonet.

Another remarkable feature was the universal use of telephones, the systems being carried right up into the firing line. Undoubtedly the telephone must play an important part in future siege warfare.

In conclusion Colonel Nicholls derives two great lessons from the Siege:—

(1). Now more than ever the capture of a properly fortified fortress, defended by good troops, can only be effected by resort to regular siege operations, which involve the expenditure of much time, material, and labour, and in which the art of the engineer and the skill of the gunner must first prepare and make possible the infantry assault by which alone final success can be achieved.

(2). Therefore it behoves the officers of every arm to learn the principles and methods of Siege Warfare, and to understand the limitations of the different arms, so that they may not through ignorance be led to embark on operations that must be foredoomed to failure.

A. T. MOORE.

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NATURE.

April, 1907.

GYROSCOPIC APPARATUS FOR STEADYING SHIPS (*p.* 561).—An old first-class torpedo-boat, the *Seebar*, has been lately fitted up with a gyroscopic apparatus and trials have been made with it by Dr. Otto Schlick on the Elbe. The *Seebar* is 116 feet long, 11·7 feet wide, 3·4 feet draught, and of 56 tons displacement. Her metacentric height was 1·64 feet, and her period of oscillation, or double roll, 4·136 seconds.

The outside diameter of the fly-wheel of the gyroscope was 1 mètre, its weight 1,106 lbs., and the peripheral velocity at which it was run 274·8 feet per second, the number of revolutions being 1,600 per minute. Blades were fitted to its periphery and steam was admitted direct through the hollow trunnions, so as to work the fly-wheel as if it were a turbine.

Still-water rolling experiments were made with the *Seebar*, rolling being set up by the crew running from side to side. It was found that with an initial angle of inclination of 10° and with the gyroscope at rest, 20 single oscillations took place before the extreme inclination to the vertical was reduced to ½°; whereas the same amount of extinction was obtained with little more than two single oscillations when the gyroscope was free to oscillate and the fly-wheel was making 1,600 revolutions per minute; this proved the enormous extinctive effect of the gyroscope.

The principle of gyroscopic action is fully explained in a previous paper by Dr. Schlick. Lord Kelvin designed an instrument, called the gyrostat, to illustrate the more complicated state of motion of a spinning body when free to wander about on a horizontal plane, like a top spun on a pavement, or a hoop or a bicycle on the road. It consists essentially of a massive fly-wheel concealed in a metal casing; and its behaviour on a table, or with various means of suspension or support, serves to illustrate the curious laws of statical equilibrium due to the *gyrostatic domination* of the interior invisible fly-wheels when rotated rapidly.

It is by the adoption of the gyroscopic apparatus that the efficiency of the Whitehead torpedo has been enormously increased. When the projectile is discharged its gyroscope is set going, and it is bound to run in the line it was pointing when the fly-wheel was started; thus all inaccuracies of flight, due to errors of adjustment or even damage to some part, are eliminated.

Experiments have been similarly made by Sir J. Thorneycroft with his steam yacht *Cecili* and also by Mr. Tower with his steady gun platform controlled gyroscopically.

Sir W. White has discussed the further application of the principle to war vessels, and, though he did not commit himself to any definite opinion, it may be said that the impression given was decidedly of a hopeful nature.

W. E. WARRAND.

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REVISTA DE ENGENHERIA MILITAR.

January, 1907.

ENTRENCHED CAMP OF LISBON.—The organization of the Entrenched Camp of Lisbon is to be altered in a few details. The whole of the fixed defences are to be placed under a sole military authority. To this end the submarine mining and torpedo services are to be separated, and the former is again to be placed under the War Office, under which department it was originally organized.

ENGINEER TROOPS; THEIR ORGANIZATION AND TRAINING.—By Colonel Dias of the Engineers.—Refers to previous articles by the same author in the *Revista* of May, June, and July, 1906, and then deals in detail with the proposals of Lieut. Ferreira which appeared in the September number. These proposals concerned:—

(*a*). The formation of an Auxiliary Corps of Military Engineers.
(*b*). The formation of Transport Companies for Engineer Services.
(*c*). The attendance of Cavalry and Infantry officers at the Engineer Schools of Instruction.
(*d*). The command of the Parks of the companies of the Engineer Regiment by officers of the Ordnance Corps.*
(*e*). The arms to be issued to the personnel of the Field Telegraph Companies.

Colonel Dias does not altogether agree with (*a*), but considers that the formation of an auxiliary corps of non-commissioned officers, performing the duties of foremen of works and draughtsmen, is desirable. With regard to (*b*) he considers the present system, by which each engineer company has its own transport and drivers, is the more suitable. He concurs in (*c*). As to (*d*) he thinks that the idea is excellent but that it would be difficult to carry out, and prefers giving the command of the parks to mounted sergeants of the companies. If, however, his own scheme of dividing the engineer regiment into 3 battalions (each with its own park) were adopted, he thinks it would be desirable that the parks should be commanded by Ordnance officers. With regard to (*e*) he thinks that Lieut. Ferreira's proposal to arm the telegraphists with carbines, which would as a rule be carried in the telegraph equipment carts, deserves a trial.

APPLICATION OF A LIGHT AFRICAN BRIDGE TO FIELD SERVICE.—An account of experiments made at Tancos in April, 1906, by the Engineer School of Instruction with a form of native bridge used in Africa. The bridge is formed of a number of two-legged trestles, consisting of two standards connected together with a long foot-sill near their feet and a short transom near their tops, planks being laid along the transoms; the whole stiffened by longitudinal braces. It is only suitable for the passage of infantry in single file; but where trees of small diameter (from $2\frac{3}{4}''$ and upwards) are alone available, such a bridge might be useful. Rivers

* *Reviewer's Note.*—This corps consists of two classes:—(1) engineer and artillery ordnance officers, (2) medical ordnance officers. The officers of (1) are obtained from the sergeant-majors and colour-sergeants of the engineers and artillery, who supply the commissioned ranks of the transport company

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330 yds. wide, 16 ft. deep, and with a current of 10 miles an hour, have been crossed by this means. The article, which is continued in the February number, is illustrated by photographs, and treats the various cases in considerable detail.

HISTORICAL DOCUMENTS (18TH CENTURY).—Reprint of a "Memoir on the Exercise of Military Thought" by the Count of Schaumbourg-Lippe, Marshal of the Armies of His Most Faithful Majesty. Recommends officers to study their profession both by reading military works, and by solving military problems which are to be set them by the colonels of their regiments. Though published in 1782 the memoir bears a strong resemblance to the orders and regulations on the subject issued at the present day. It may be interesting to give a list of the works recommended :—

The Art of War, by the Marechal de Puysegur, 2nd Vol. especially.
Memoirs of the Marquis de Feuquieres.
The Instructions of the King of Prussia (Frederick the Great) to his Generals.
The Memoirs of Montecuculi.
The Military and Political Reflections of the Marquez de Santa Cruz.
Practical Art of War, by Ray de St. Genies.
Small Wars, by Grand-Maison.
A Treatise on Small Wars, by La Croix.
Field Engineering, by Clairae.

February, 1907.

SOME EXTRACTS FROM THE REPORT OF ENGINEER REGO LIMA ON HIS MISSION TO THE MINES OF CASSINGA IN 1898.—Continued from page 472 of the previous volume.—Cassinga is located on one of the tributaries of the Cunene in the Ambuella district of Angola. This portion of the report deals with the journey from San Pedro de Chibia to Quipungo. A good description of the country and its geological features.

HISTORICAL DOCUMENTS—CIRCULAR OF THE COUNT OF LIPPE CONCERNING SCHEMES AND EXERCISES FOR THE ATTACK AND DEFENCE OF FORTRESSES.—This circular was issued in September, 1773, to the Governors and Commandants of the principal fortresses of the kingdoms of Portugal and the Algarves, and directs them to prepare defence schemes for their respective commands, the schemes to be sent to the War Minister. Great stress is laid on their value, and the commanding officers are directed to mobilize their fortresses on the 1st or 2nd day of every month. The Engineers on these occasions are to point out to the officers commanding each work and covered way how the troops should be employed according to the different modes and periods of the attacks; what they should do in the covered ways, places of arms, ravelins, tenailles, etc.; the use of traverses, caponiers, counterscarp galleries, etc.; how the enemy's lodgments should be prevented; the dispositions for resisting all kinds of assaults; operations for retaking works that may have been lost; means of communication, and of retiring when it is impossible to hold out any longer. The whole circular is conceived in a most modern spirit.

M.

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REVUE DU GÉNIE MILITAIRE.

March, 1907.

VENTILATION OF CONCRETE CASEMATES.—The system described consists of a centrifugal air pump, which delivers a stream of fresh air through a perforated pipe laid below the guard beds, with which the casemates are furnished. The minimum allowance of fresh air is 5 cubic mètres per man per hour. In the absence of any description of the French casemates, it is not easy to understand why so complicated a system is necessary.

UNDERGROUND SHELTERS.—The Japanese during the late war constructed a number of subterranean dwellings for their troops. The simplest were square or round holes 9 feet in diameter and 6 feet deep, roofed with millet stalks. The most usual form was a rectangular excavation 15′ × 12′ × 6′, covered with a roof of millet stalks and mud. At one end was a mud wall containing a paper window and a door, and at this end a ramp led down to the shelter. Several hospitals were constructed in a similar manner.

THE PURIFICATION OF WATER.—A large quantity of permanganate of potash is first added to the water; this destroys all microbes. To get rid of the permanganate some manganese sulphate is added, which causes all the manganese to be deposited as manganese dioxide, leaving only a small quantity of potassium sulphate dissolved in the water.

J. E. E. CRASTER.

RIVISTA DI ARTIGLIERIA E GENIO.

March, 1907.

THE NEW TENDENCY OF SIEGE TACTICS AND PREPARED FIRE FROM FORTRESSES.—A long and able article by Capt. Ottolenghi of the General Staff. The general scope is antagonistic to a too rigid system for the preparation of fire from siege batteries in fortresses, as involving great labour and cost, whilst there is a chance that, when the time comes, it may be found impossible to employ the fire.

The prepared fire of to-day is an ingenious conception, which, when proposed 20 or 30 years ago by Colonel Bellini, was expected to give the best practical results in relation to the then prevalent ideas regarding the attack and defence of fortified places. Since then several lustres have passed. The technical procedure remains the same, but the tactical considerations have greatly altered and have conduced to entirely new views of the art of fortification and siege tactics. If siege warfare was carried on according to the principles which regulated it thirty years ago, and if at the same time artillery could only be employed from the places fixed at the end of a time of peace, no one would take exception to the prepared fire of to-day. But it is not so! In the face of the mutability of such an idea, and of the feverish progress incessant in all branches of

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military activity, a rigid technical system, which is not susceptible of rapid radical changes, which renders difficult the adoption of expedients in cases of unexpected emergencies, and which does not take into note that in siege warfare as in field operations the conduct of the operations should be essentially tactical, requires to be modified or abandoned.

With an over-rigid system the defender will not be able to take up positions selected at the moment outside and at a distance from the permanent works, and he will thus be unable to make use of his entire forces. It is exactly this selection of positions that cannot always be foreseen in time of peace, because it is frequently governed by the actions of the enemy. In positions hastily taken up it may not be possible to prepare the fire in accordance with the prescribed regulations, and this shows the necessity of preparing in time of peace, with great care, only what may be called the *constant elements* of fire, and of taking such constant elements as a basis for calculating *in a hasty manner* (in the time that may be available after the declaration of war and before the investment of the place) all the other elements necessary. For the determination of these latter a method should be adopted which can easily be modified or radically changed and adapted quickly to all the new circumstances, foreseen and unforeseen, in the defence of a fortified work.

THE EMPLOYMENT OF BALLOONS IN THE RUSSO-JAPANESE WAR is dealt with in the Supplement No. 95 (February, 1907) of the *Internationale Revue*. The Siberian Balloon Company, formed during the war, arrived at the theatre of operations at the end of June, 1904, and proceeded as soon as possible to join the Xth Corps. It had 90 wagons, 26 with the first detachment and 64 in a second detachment behind. After a very fatiguing march, much delayed by the bad state of the roads, the company was sent to Kudsia, 40 k.m. to the east of Liaoyang, on the left wing of the Russian position. At about 15 k.m. from Kudsia the balloon was inflated and the first ascent was made on the 23rd July, General Slutchewski, commanding the Xth Corps, being present. The Japanese positions, distant only 5 k.m., were fully reconnoitred, and it was possible to distinguish individuals. The company in accordance with orders came by Liaoyang toward Haitchang, but was not employed there because the Russians had retired.

Having been placed under the orders of the General Commanding the Engineers it again came into action on the 23rd August; and on the 31st it was able to observe the Japanese forces which were endeavouring to accumulate on the right Russian wing. Marshal Oyama himself admitted that he had been obliged to modify his dispositions owing to observation by the balloon.

The Japanese artillery from their well-concealed camp fired upon it with shrapnel. Some of the projectiles exploded very near to the balloon, both before and behind it, but without causing any losses. Later on it was again exposed eight times to a similar fire, but always without effect. This experience confirms the difficulty of hitting a balloon, and even when it is struck the effect is not necessarily fatal. The Russian balloon was a spherical one, silk, on the Riedingen system.

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On the 1st September the balloon was again utilized for taking observations, and sustained the enemy's fire without being struck, although the projectiles aimed at it were a source of danger to the IVth Siberian Corps in its rear.

The Company arrived at Mukden on the 6th September, 1904. Later on it participated in the offensive movement on Scia-ho, accompanying the advance guard of the Xth Corps. On the 5th October the balloon made a few ascents, and observations were made of the positions of the enemy's batteries. It was again fired at several times without any effect except a small wastage of the gas.

The Company then returned to Shahepu and Peitapu. Three crosses of St. George were awarded to it for its brilliant services.

On the formation of the IInd and IIIrd Army Corps of Manchuria it formed the nucleus for the Aeronautic Battalion of East Siberia.

Little experience was gained in the employment of balloons in fortress warfare. At the commencement of the siege Port Arthur did not possess any, and some material sent in the skiff *Mancuria* was captured by the Japanese. During the siege Lieut. Lawron constructed a spherical silk balloon and a canvas kite, but the material used was ineffective. Later on there was a failure in the supply of gas.

The Japanese also adopted a balloon of special construction; but they were far from obtaining satisfactory results. It was of little use for observing the movements of the enemy's ships; and the observations made were not sufficiently accurate to enable them to regulate the fire of heavy artillery. It was only after the capture of the 203-Mètre Hill that they were able to obtain a direct view of the Port and bring an effective fire against the Russian ships. If the balloon service had been better organized, it might have rendered unnecessary the capture of this hill, which was taken at such great sacrifice.

The experience gained from the employment of balloons in the late war has not been very rich in results; but it has shown once more that the pack wagons should be as light as possible, and that hostile fire cannot easily place balloons out of action. It is more important to note that in all cases an improvised service is of little value; only a complete organization, fully experimented with in time of peace, can give good results in war.

EDWARD T. THACKERAY.

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RECENT PUBLICATIONS.

Manual of Sanitation in its Application to Military Life. Official. (7½ × 5. 52 pp. 2d. Wyman).

Military Law Made Easy, by Lieut.-Colonel S. T. Banning. 3rd edition, revised. (7½ × 5. 4s. 6d. Gale & Polden).

Scouting and Reconnaissance in Savage Countries, by Capt. C. H. Stigand, Roy. West Kent Regt., author of "Central African Game and its Spoor." In pocket-book form, with scales on cover, and blank ruled pages. (7 × 4. 5s. Hugh Rees).

De la Restitution du Plan au moyen de la Téléphotographie en Ballon, par Capt. L. Pezat. (8vo. 2 fr. Berger-Levrault, Paris).

Studien über den Krieg. Teil 3. Strategie. Heft 6. von General J. v. Verdy du Vernois. (8vo. Berlin).

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Marokko. Eine Militärische Studie, von Oberstleut. Hübner (Beiheft zum *Militär-Wochenblatt*). (9 × 6. Mittler, Berlin)

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A Nation in Arms. Speeches on the Requirements of the British Army, delivered by F.M. Earl Roberts, V.C., K.G. (7 × 4½. 1s. Murray).

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The Allies, by Major-General Sir Henry Colvile, K.C.M.G., C.B. (9 × 5½. 16s. Hutchinson).

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,, J. P. Mackesy, R.E.
,, B. W. B. Bowdler, R.E.
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*Capt. R. G. Parker, Rl. Lancaster Regt.
Capt. G. N. T. Smyth-Osbourne, Devonshire Regt.
Capt. V. H. M. de la Fontaine, East Surrey Regt.
Capt. and Bt. Major F. R. Hicks, Hampshire Regt.
Capt. H. S. Williams, Dorsetshire Regt.
,, B. D. L. G. Anley, D.S.O., Essex Regt.
Capt. R. S. Hamilton-Grace, Durham Light Infantry.
*Capt. H. F. Baillie, Seaforth Highlanders.
,, P. S. Allen, Gordon Highlanders.
,, J. K. Cochrane, Leinster Regt.
,, R. L. Ricketts, Indian Army.
,, W. K. Bourne, Indian Army.
,, F. W. Lumsden, R.M.A.

The following Officers received nominations:—

Capt. H. C. Bickford, 6th Dragoon Guards.
Capt. C. J. C. Grant, Coldstream Guards.
Capt. W. D. Wright, V.C., Royal West Surrey Regt.
Capt. C. H. Harington, D.S.O., Liverpool Regt.
Capt. H. Wake, D.S.O., King's Royal Rifle Corps.
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89th	W. G. Bagot-Chester..... 4,115	190th	R. M. Aylmer..... 3,339
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115th	D. M. Black 3,940	213th	B. W. Molony 2,881
125th	W. J. King-King 3,846		

WOOLWICH, JUNE, 1906.

31st ... ... J. S. Barkworth 6,483

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SECOND	H. G. MacGeorge 7,196	16th	R. Crofton 6,330
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